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Managing Southern Forests for Wildlife and Fish

A Proceedings

MANAGING SOUTHERN FORESTS FOR WILDLIFE AND FISH

A PROCEEDINGS

EDITED BY JAMES G. DICKSON AND O. EUGENE MAUGHAN

I

Preface

Southern forests are very productive for wildlife as well as wood fiber. User recreation demands for game and nongame wildlife and fish continue to increase as human populations grow in the sunbelt. The main determinant of wildlife populations is suitability of forest habitat and the primary manipulator of the habitat is the forester. Forestry decisions and practices determine habitat suitability for wildlife communities and ultimately wildlife populations. With this publication we plan to demonstrate how southern forests can be managed for the myriad of wildlife species. General topics in the publication relating to wildlife communities include economics of accommodating wildlife and fish, impact of specific forestry practices, special techniques, agency policy and practices, and prospects for the future. Although earlier drafts of these papers were edited, the content of each final manuscript was the responsibility of each author. We thank Ronald Thill, Alexander Zale, Hugh Black, Lowell Halls, Roger Baker, George Hurst, and James Neal for assistance in reviewing these manuscripts. This publication is from the proceedings of the Wildlife and Fish Ecology Technical Session, 1986 Society of American Foresters National Convention, Birmingham, Alabama.

James G. Dickson
O. Eugene Maughan, editors

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Introduction

Thomas H. Ellis

It is a pleasure for me to introduce the 1986 technical session of the Working Group on Wildlife and Fish Ecology. The title of this technical session, "Managing Southern Forests for Wildlife and Fish," is an intriguing one. It incorporates elements of a basic fact, of a general area of professional controversy, and of an ever-increasing public interest. It is a fact that southern forests, under almost any sort of forestry program, are major producers of wildlife and the sources of a huge proportion of all the fresh water supplying southern streams and lakes. Nothing short of wholesale conversion to agriculture could alter this situation significantly.

The disputes between foresters, wildlife professionals, and water resource managers over relative priorities among timber, wildlife and water are legendary and intensely frustrating to all sides. Public sentiment seems generally favorable toward trees, animals and fish of all sorts, is largely uniformed and appears to increase in passion as wealth and education and urbanization of the human population grow. Further, the spectrum of groups who have legitimate interests in forests, water and wildlife grows more and more varied every year.

In this situation, one would hope that there would be grounds for common cause among the natural resource professions, and with environmental interest groups, toward public and private policies that would best serve the long-run interests of our region. Technical information, from experts such as the members of this working group, is essential to the search for such policies.

The South presents particularly important opportunities for alliances among natural resources professions for several reasons. First, the nature and history of southern forests typically have not led to as sharp conflicts between foresters and other professions as occur regularly in the West. Most of our forest acreage here is privately owned and has been logged repeatedly in the past 100 years. We have little virgin forest to draw arguments over preservation. And, until recently, Southerners have enjoyed less wealth and education than people in other regions and been less disposed towards environmental concerns.

Second, demographic statistics and the newspapers make it clear that the situation in the South is changing. The southern states are increasing dramatically in population, educational levels and wealth. The influences of urban populations more and more are noticed in state legislatures, in local land use restrictions, and in recreational uses of public and private lands. Although there still are large areas of the South where foresters, especially on private lands, have little interference from environmental concerns, we appear destined to suffer the same kinds of frustrations that our western colleagues have--unless we have the foresight to anticipate the most important issues and take action on them now.

Land use shifts between agriculture and forestry in the South are commonplace and there is enormous potential in either direction. The environmental benefits of timber management as compared to farming, mining, and real estate development seem so great that there should be a fundamental case for foresters to seek support of commercial forestry from groups which often oppose it.

The least effective strategy for foresters would be to write off complaints from other professions or interest groups as unimportant. In my view, the most useful approach is for foresters to demonstrate a strong concern for the environment, to seek effective ties with other natural resource professions and environmental organizations, and to marshal good information on the influences of timber management on wildlife, fish, and other resources.

Research on the environmental influences of timber management has been going on for years in the South, with some excellent results. Examples include comprehensive work on white-tailed deer, a great deal of information on quail and turkey habitat requirements, and extensive research on effects of harvesting on mountain watersheds. In contrast, we have not much data relating forestry and most non-game animals (which now may occasion more serious controversy than game species) or on forestry and water management in the coastal plains. In many instances, we have case studies for a particular locale but inadequate information for regional issues. We particularly lack quantitative functions which would predict the levels of output for other resources in relation to changes in timber production. This is a very tough challenge but one we must meet in order to avoid or meet court challenges and to hold the public's confidence.

Today's working group session brings together speakers with outstanding credentials for viewing many aspects of our topic--Managing Southern Forests for Wildlife and Fish. Some of them are researchers; others are people with immediate responsibility for reconciling land management issues. All are people who are dealing with questions of great, long-run importance for southern forestry.

Thomas H. Ellis, Director, USDA Forest Service, Southern Forest Experiment Station, New Orleans, LA

Economics of Accommodating Wildlife

C. William McKee

Abstract.--Revenues generated from timber production alone are compared with joint timber-wildlife production. Net revenues from joint timber-wildlife production exceed revenues from timber alone. The increased revenue should provide added incentive for forest landowners, particularly nonindustrial landowners, to practice better forest management.

INTRODUCTION

In recent years, intensive forest management has received considerable attention from sportsmen and concerned conservationists. Some contend that converting large areas of mixed pine-hardwood stands to intensively managed short-rotation pine plantations will adversely affect wildlife populations. Others contend that age-class distribution of pine stands, streamside management zones (Section 208, Public Law 92-500), prescribed burning and thinning will increase habitat diversity and, thus, enhance certain wildlife populations. In other words, the quality of forest wildlife habitat depends upon the type of timber management practiced (Halls, 1975).

In the past, forest managers have been led to believe that adopting wildlife habitat enhancement guidelines will have an adverse effect on the business' basic objective of maximizing profit. The industrial forest manager has been forced to make decisions oriented toward maximizing profits because tradition has led him to believe that wildlife habitat enhancement can only be achieved at the expense of timber production. More recently, forest management strategies have been adjusted to accommodate increasing demands for all forest resources.

The purpose of this paper will be to identify the economic problems and constraints associated with the assessment of wildlife habitat tradeoffs and to determine the impact of habitat enhancement on dollar returns of a typical forest management strategy.

ECONOMIC PROBLEMS AND CONSTRAINTS

Market value is the commonplace and common sense approach to setting values in our democratic society. We experience it daily everytime we make an exchange in the market place as a willing buyer with a willing seller or vice versa. Such exchanges represent most of the goods and services we acquire or provide for others. Where markets do not exist, as is the case with wildlife and other recreational activities, a proxy for market product dollar returns must be developed. Many studies discuss comparing non-market products with marketable products (Bockstael and McConnell 1978, Gibbs 1975, Martin et.al. 1974).

One technique involves assessment of investment in terms of opportunity costs. For example, if timber is produced jointly with recreation or hunting opportunities, revenues from timber normally decline. The reduction of revenues from timber is considered an opportunity cost in that income must be foregone in order to accommodate other outputs. Loss of timber revenue then becomes an estimate of value for the non-timber outputs. The opportunity cost approach will be used to assess timber-wildlife habitat tradeoffs in this paper.

ANALYTICAL METHODS AND ASSUMTIONS

Discounting Models

Various methods are used to estimate the profitability of a timber production investment. The most acceptable method, however, for appraising long-term projects such as forestry is discounted cash flow or present net worth (PNW) analysis (Gunter and Haney 1984). The superiority of the technique, and the characteristic which distinguishes it from others, is its recognition that money has a time value. PNW calculations give us a dollar figure which tells how much our forestry investment will return. A positive PNW tells us that our investment will return more than the interest rate we choose for discounting--say 12%.

Another economic indicator which is based on PNW is annual equivalent. It automatically adjusts a timber investment, regardless of rotation length, to a one-year equivalent. Annual equivalent thus provides a convenient way of comparing a timber

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enterprise with shorter-term uses of the land such as cropping or recreations.

Assumptions

To assess economic returns for a typical forest management strategy, we must make assumptions concerning discount rates, expected costs, timber yields, and stumpage prices.

Discount rates for the analysis were set at 6% in constant or real dollars. A 6% real, or constant dollar, discount rate translates to a 10% nominal or market rate if inflation is 4%.

Investors in timber growing may have to buy land; prepare planting sites; plant, release, thin, protect, and prune trees; prepare and administer timber sales; install hardwood leave strips (Streamside management zones); and pay annual taxes. Not every timber grower will have all of these expenses, but all will have some costs in growing timber. Such costs can be thought of as investments that must be made to grow a certain kind of timber in a certain way. Expected costs for this analysis are presented in Table 1.

Before timber sale incomes can be derived an estimate of what kind and how much timber will be available for sale throughout the rotation must be determined. Loblolly pine yields for average site (SI$_{25}$60) land are presented in Table 2 (Hepp 1985). 'PW' and 'ST' denote pulpwood harvested in cords per hectare and sawtimber harvested in thousand board feet Scribner per hectare, respectively.

Table 1.--Direct costs of intensive forest management for timber production only and joint timber-wildlife production[a]

Year	Timber only	Timber and wildlife	Today's cost	
			($/ha)	
1	Site Prepare	Site Prepare	222.39	(90)
1		SMZ installation[b]	14.83	(6)
2	Plant	Plant	135.91	(55)
8		Precommercial thinning	111.20	(45)
8 to 35 3 year intervals		Prescribe burn	19.77	(8)
12 to 35, 5 year intervals	Prescribe burn		19.77	(8)
Annual	Management costs	Management costs	12.36	(5)
Annual	Taxes	Taxes	3.71	(1.50)

[a] Per acre values are in parentheses.

[b] 6.5 hectacre (16 acre) Streamside Management Zone.

Table 2.--Per hectare loblolly pine yields for timber production only and joint timber-wildlife production[a]

Management	1st Thinning			2nd Thinning				Harvest		
Regime	Age	RBA[c]	PW	Age	RBA	PW	ST	AGE	PW	ST
Timber	15	198 (80)	30.6 (12.4)	25	198 (80)	23.5 (9.5)	3.9 (1.6)	35	32.9 (13.3)	21.1 (8.6)
Timber & Wildlife[b]	15	148 (60)	19.8 (8.0)	25	148 (60)	16.1 (6.5)	6.7 (2.7)	35	15.1 (6.1)	22.0 (8.9)

[a] Per acre yields are in parentheses.

[b] Precommercial thinning at age 8, residual component of 350 stems per acre.

[c] 'RBA' denotes residual basal area in square feet per hectare.

The last assumption needed to assess economic returns is stumpage price. Stumpage prices used are based on the average price reported, 1980-1986, in Timber-Mart South for Alabama (Table 3). No real price increase in pulpwood or sawtimber stumpage is assumed.

Table 3.--Average stumpage price for various forest products, Alabama, 1980-1986

	Pulpwood	Sawtimber
	($/cord)	($/MBF, Sc)
High	20	166
Medium	16	149
Low	12	116

APPLICATIONS AND RESULTS

For our purpose, we want to establish maximum financial returns as the goal of our forest manager. With this as our objective, an assessment was made for managing a 65 hectare (160 acre) tract for timber only and joint timber-wildlife production. The management strategy and expected yields have been presented (Tables 1 and 2). To enhance diversity, however, ten percent of the 65 hectares (16 acres) is assumed to be managed as a streamside management zone under the joint timber-wildlife option. The streamside management zone will be managed for production of high quality hardwood saw-timber. Periodic harvests will be made every ten years.

Economic returns for our two management options - 1) timber production only versus 2) joint timber-wildlife production are found in Table 4. Present net worth and annual equivalent values indicate that there is an opportunity cost associated with managing for both timber and wildlife. The timber revenue foregone column of Table 4 represents the opportunity cost of the amount of timber revenue that must be sacrificed to accommodate wildlife habitat enhancement.

Table 4.--Opportunity cost of providing improved wildlife habitat[a/]

Stumpage Option	Management Regime	Present Net Worth	Annual Equivalent	Timber Revenue Foregone
		($/ha)	------------------($/ha/year)----	
High	Timber Only	433.14 (175.29)	29.87 (12.09)	12.23 (4.95)
	Timber & Wildlife	256.04 (103.62)	17.64 (7.14)	
Medium	Timber Only	280.36 (113.46)	19.35 (7.83)	10.72 (4.34)
	Timber & Wildlife	125.18 (50.66)	8.62 (3.49)	
Low	Timber Only	57.55 (23.29)	3.98 (1.61)	8.70 (3.52)
	Timber & Wildlife	-68.32 (-27.65)	-4.72 (-1.91)	

[a/] Per acre values are in parentheses.

A variety of options are available in forest management. Landowner objectives determine how forest holdings are managed. If the landowners objective is joint timber-wildlife production, loss of timber revenue can be offset by leasing hunting rights. What is an appropriate lease fee? Landowners will not incur a loss for increasing their management efforts if they charge leasees $8.70 to $12.23 per hectare per year ($3.52 to $4.95 per acre per year). Results of a telephone survey of Alabama forest industry and large landowners revealed that current hunting leases range from $2.47 to $51.89 per hectare per year ($1 to $21 per acre per year) with an average beginning $12.36 per hectare per year ($5 per acre per year). Hunting lease fees are extremely sensitive to management services provided by the landowner and to population levels of the preferred game specie. For the moment, assume that the landowner can lease his land for $12.36 per hectare per year. This fee will buy the leasee the type of wildlife habitat provided by the joint timber-wildlife management strategy identified in Table 1.

Compared to the timber only strategy, a $12.36 per hectare per year lease fee will increase landowner revenue by $0.99 to $4.52 per hectare per year ($0.40 to $1.83 per acre per year) (Table 5).

DISCUSSION

The most apparent conclusion from Table 5 is that net revenues from timber-wildlife management strategies exceed profits from timber alone. This is of particular significance for nonindustrial landowners since it gives them the opportunity to earn annual income from hunting.

Table 5.--Joint timber-wildlife economic returns for an annual lease rate of $12.36 per hectare per year[a/]

Stumpage Option	Present Net Worth	Annual Equivalent	Revenue Gain Over Timber Only Regime
	($/ha)	---------$ per hectare per year	
High	447.52 (181.11)	30.86 (12.49)	0.99 (0.40)
Medium	316.53 (128.14)	21.84 (8.84)	2.50 (1.01)
Low	123.13 (49.83)	8.50 (3.44)	4.52 (1.83)

[a/] Per acre values are in parentheses

The added income partially offsets a major drawback of timber investments for these owners, namely, the long time period between initial expenditures and generation of revenues.

Owners of industrial forest land have a somewhat different perspective on their role in creating and maintaining wildlife habitat diversity. As Lewis (1983) notes, "Forest industry operates within a mixed market economy and owns forest land for one or more of three basic reasons. The first of these is to insure an adequate supply of raw material for processing plants. The second is to speculate on the increased value of both land and timber. The third is to earn a return from the biological growth on a forest property."

Diversity, a key component of wildlife habitat, within the intensively managed forest is the result of decisions relating to size, shape, and distribution of pine plantations and the maintenance of other habitat types in streamside management zones and non-intensive management areas. Deviation from a corporate/regional timber management strategy to enhance wildlife habitat diversity increase the firm's direct costs. Some examples include breadup of natural compartments into separate units, and harvest and silvicultural treatments are not carried out at the optimum time. McKee (1983) estimates these direct costs to range from $2.08 to $8.01 per hectare per year ($0.84 to $3.24 per acre per year). On a per cubic foot basis this amounts to additional costs of $0.08 to $0.32. Pine stumpage in Alabama is currently $0.55 per cubic foot. Consequently, the direct cost of enhancing wildlife habitat amounts to 14 to 58 percent of the stumpage value. This is significant because it adds to investment cost without increasing timber yield. Additional direct costs incurred by the firm include increased road maintenance and fire protection, and control of public access.

SUMMARY AND CONCLUSIONS

Managing for timber production only will provide some habitat diversity. Enhancing wildlife habitat to a higher degree can only be achieved by altering silvicultural treatment and size, shape and distribution of management units. These activities have a cost associated with them which can be measured by lost timber revenue.

Forests produce multiple outputs and are often managed on a multiple-use basis. Results from this analysis should help quantify the public relations cost associated with enhanced wildlife habitat.

Where joint timber-wildlife production is the goal, a careful analysis of market opportunities for lease hunting should be made. If the markets are there, all indications suggest that management for joint production of timber and wildlife is more profitable than timber alone. The possibility of hunting lease income should provide additional incentive to owners of forest land, especially nonindustrial landowners.

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Some Economic Benefits of Protecting Water Quality

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and
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Abstract: Often water quality management is viewed as a cost with no financial return for the investment, but protecting water quality for fisheries can have positive economic returns to the forest landowner. Many of the practices used to protect water quality are the same ones done to protect or improve soil productivity. Protecting or improving soil productivity means more timber produced per acre, which is translated into economic returns to the landowner. Also, erosion and sediment control practices can save in road construction and maintenance costs.

INTRODUCTION

Erosion produces sediment and sport fishery habitat is adversely affected by escessive sediment. Erosion control in forests can provide significant economic returns to landowners from increased timber production, savings in site preparation, road construction, and road maintenance costs.

In forest management, practices to reduce erosion are often the same ones needed to maintain or improve soil productivity. For example, to lower erosion, ground cover is increased by leaving litter and debris in place. Also, care is taken to decrease soil compaction and displacement. Reducing soil exposure, displacement, and compaction leads to maintaining or improving soil productivity, thus sustaining or increasing timber production. It is through maintaining or improving timber growth and yields that landowners and ultimately society benefit economically (Dissmeyer 1985).

SEDIMENT AND FISH HABITAT

Fine sediment has negative impacts on habitat for rainbow trout (salmo gairdneri), smallmouth bass (micropterus dolomieui), and largemouth bass (micropterus salmoides). Raleigh et. al. (1984) identifies two habitat factors for rainbow trout that are adversely affected by increasing amounts of sediment: predominant substrate type in riffle-run areas for food production and percent fines in riffle-run and spawning areas during average summer flows. Edwards et. al. (1983) reports that fine sediments affect smallmouth bass habitat suitability indexes for dominant substrate type within pool, backwater or shoal areas, and maximum monthly average turbidity level during the summer. Stuber et. al. (1982) identify maximum monthly average turbidity during the growing season and substrate composition within riverine pools and backwaters or lacustrine littoral areas as factors that influence largemouth bass.

Stowell et. al. (1983) developed a model to predict sediment yield and fish populations for Forest Land Management Planning in the Idaho Batholith. The model was built using available research results and field data. The model was validated to give reasonable estimates of fish population responses to varying sediment yields from different management scenarios. The sediment yield model accounts for erosion from various sources, estimates how much of the eroded material enters the stream network, and is transported to the stream segment where a fish response is approximated.

Stowell et. al. (1983) presents several habitat and fish response curves for sediment impacts. The percentage of fine sediment (particles in the channel that are less than 6.4mm in diameter) rises as the percent sediment yield over natural yield increases (Fig. 1). As sediment yield increases, embeddedness increases and the impact upon fish increases. Embeddedness is a rating of the degree the larger particle sizes (e.g., gravel, rubble, and boulder) are covered by fine sediment.

The model developed by Stowell et. al. (1983) translates fine sediment and embeddedness into estimates of percent fry emergence, summer rearing capacity, and winter carrying capacity for rainbow trout (Fig. 2). Fry emergence shows a precipitous drop between 20 and 30% fine sediment and is near zero at 40% fines. Figure 1 suggests that increasing sediment by 100% over natural yields will increase fine sediment in the streambed from 20 to 30%. A 180% increase in sediment yield would result in 40% fines.

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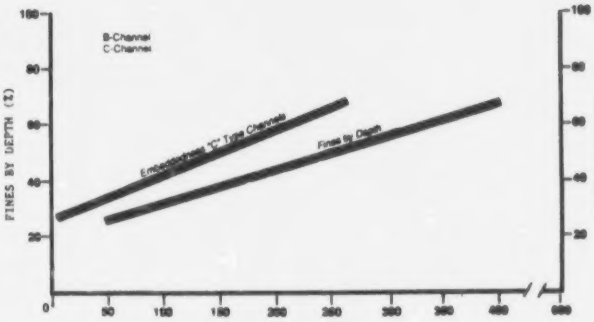


SEDIMENT YIELD OVER NATURAL (%)

Figure 1 - Sediment yield over natural versus fines by depth response curve for "B" and "C" channels, and versus embeddedness. Clearwater and Nez Perce National Forest's data.

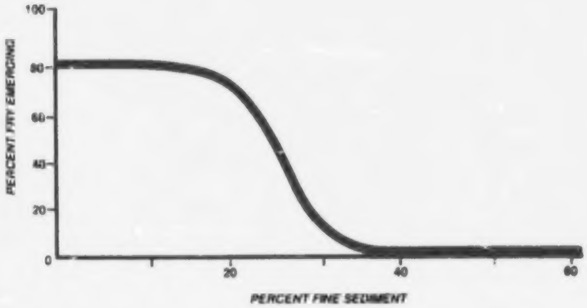
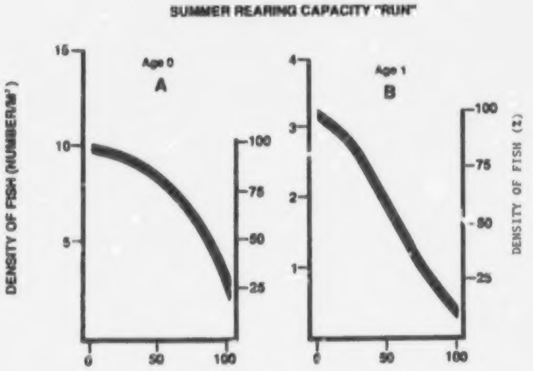
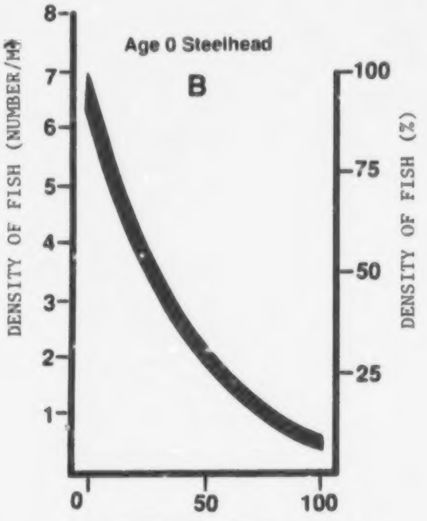


Figure 2 - Fine sediment by depth versus alevin (fry) emergence response curve for rainbow steelhead trout.



EMBEDDEDNESS LEVEL (%)

Figure 3 - Relationship between summer rearing capacity (density of fish in numbers of fish/m and as a percentage) and substrate embeddedness in runs from age 0 and 1 rainbow trout.



EMBEDDEDNESS LEVEL (%)

Figure 4 - Relationship between winter carrying capacity of pools (density of fish in numbers of fish/m and as a percentage) and subtract embeddedness for age 0 rainbow trout.

For age zero rainbow trout, the summer rearing capacity in runs decreases from 10 to 2 fish per square meter as embeddedness increases from 0 to 100% (Figs. 3A and 3B). Rearing capacity for one-year old rainbow trout drops from approximately 3 to approximately .3 fish per square meter. Similar results are seen with the importance of embeddedness on the winter carrying capacity in pools for young rainbow trout (Fig. 4).

The previous information has demonstrates the linkage and importance of sediment yield to trout reproduction and the carrying capacity of streams. The same principles apply to smallmouth and largemouth bass. These relationships are important to the fisheries biologist and the fisherman, but forest landowners are more interested in erosion and sediment control as it relates to returns on investments from their land.

ECONOMIC BENEFITS FROM SEDIMENT CONTROL

Erosion and sediment control for fisheries can also provide significant economic returns to landowners. From increased timber production, savings in site preparation, road construction, and road maintenance costs. As mentioned earlier, the practices used to reduce erosion and sediment are often the same ones needed to maintain or improve soil productivity.

Dissmeyer (1985) has summarized the basic principles of soil productivity as follows:

1. Site productivity is a function of site location, soil productivity, species selection, management, and mortality. Soil productivity is one factor in the equation. If other factors are held constant, the impact of management on soil productivity can be determined.
2. Three key soil factors affect forest soil productivity: soil physical, chemi-

Table 1. Analysis of Two Management Schedules on Site Productivity

		Light Site Prep.		Heavy Site Prep.	
Year	Silviculture Treatment	Value Per Hectare (1984 $)	Wood M^3/ha	Value Per Hectare (1984 $)	Wood M^3/ha
1984	Site Prep./Tree Planting	$297		$420	
1999	Thinning	252	64.2 pulpwood	180	46.0 pulpwood
2010	Thinning	526	22.3 saw timber 33.3 pulpwood	331	5.3 saw timber 22.0 pulpwood
2020	Final Harvest	2,422	133.5 saw timber 15.2 pulpwood	2,071	112.3 saw timber 22.0 pulpwood
Present Net Value (@ 4%)		$623		$304	
Internal Rate of Return		12.4% 1/		10.1%	

1/ Based on 4% inflation rate assumed.

cal and biotic properties. Silvicultural operations, such as harvesting, site preparation and controlled burning can increase or decrease soil productivity by altering one or more of these three properties. Examples of silvicultural impacts on soil properties include nutrient removal, soil compaction and soil displacement.

3. The amount of nutrients available at the time of planting governs the rate of seedling growth and early stand development.

4. Soil compaction can adversely affect tree growth and many years are needed for soil compaction to break down and the soil to regain its original bulk density.

5. Growth differences observed during the first 5 to 10 years of stand development on upland sites will presist through a pulpwood rotation and likely to a sawlog rotation.

Several studies emphasize these principles and demonstrate economic feasibility of protecting soil (Dissmeyer 1985). The way a site is prepared for planting can make a .9 to 4.3 meter (3 to 14 foot) difference in site index for pine planted in uplands. Patterson (1984) evaluated a 1.5-meter (5-foot) site index difference obtained by protecting soil through light site preparation during a 36-year pulpwood rotation loblolly pine (Pinus taeda) in Alabama (Table 1). Light site preparation included practices such as chop and light burn or chop and herbicides. Both of these approaches reduce soil exposure, soil displacement, erosion, and sediment. In contrast, heavy site preparation, bulldozing and windrowing or shearing and windrowing, impaired soil productivity by nutrient removal caused by pushing litter, debris and topsoil into the windrows, and by soil compaction. The latter treatments also increased erosion and sediment yields over those for the light site preparation. Patterson's data reveals that investing $123 per hectare ($50 per acre) more in heavy site preparation reduced present net value of the timber by approximately $319 per hectare ($129 per acre) and reduce the rate of return from tree growth by 2.3 real percentage points. The 1.5-meter (5-foot) decrease in site quality resulted in less sawtimber and more pulpwood per acre. Conversely, maintaining site quality yielded larger trees and more valuable products.

A recent economic analysis of the watershed management program for the Forest Service's Southern Region showed that a 1.5-meter (5-foot) site index difference on a 70-year sawlog rotation, where the average site index was 70, resulted in a 28 cubic meter (1,000 cubic feet) higher yield of timber produced on the higher index site. That decreased yield cost the producer $227 per hectare ($92 per acre) in yield, besides costing him $74 to $123 per hectare ($30 to $50 per acre) in site preparation costs.

Logging operations with accompanying skid trails and roads are sources of sediment. Primary skid trails and roads are heavily compacted and exposed to erosion from repeated passes by skidding equipment. Hatchell (1970) reports that primary skid trails occupy an average of 12.4% of logged areas, secondary skid trails, 19.9%, and log decks, 1.5%.

Froehlich (1979) found a moderate amount of soil compaction in the root zones of ponderosa pine (Pinus ponderosa) reduced growth by 6% over a 16-year period. For heavily impacted root zones, he reports growth was reduced by 12%. Wert and Thomas (1981) found growth of 42-year-old Douglas fir (Psuedosuga menziesii) in primary skid trails was reduced by 74% compared to trees growing in undisturbed soil.

Table 2. Analysis of economic benefits of skid trail rehabilitation in the management of 3 southern timber types.

		Timber type		
	Units	Hardwood	Hardwood-Pine	Shortleaf Pine
Rotation	Years	70	60	60
Harvest volume per hectare	M^3	301	350	420
Value per cubic meter	$[2]	28.57	42.86	64.29
Total value of timber per hectare for uncompacted soil	$[2]	8,600	15,001	27,002
Timber volume per acre on skid trails (26% of uncompacted soil)	M^3	78	91	109
Timber volume lost per acre	M^3	223	259	311
Cost per hectare for skid trail rehabilitation [1]	$[2]	900	900	900
Timber volume recovered (75% of loss)	M^3	167	194	233
Value of timber volume recovered	$[2]	4,771	8,315	14,980
Internal rate of return based upon timber volume recovered	%[3]	2.4	3.8	4.8
Net present value of timber volume recovered (@ 2%)	$[2]	1,193	2,538	4,568
B/C ratio of rehab. cost	Ratio	1.33:1	2.82:1	5.07:1

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[1] Average cost per acre of skid trail for waterbarring, ripping of disking, seeding, fertilizing, and mulching where needed.

[2] 1986 dollars.

[3] Percentage points over inflation.

Hatchell (1970) loblolly pine (Pinus taeda) found seedling establishment and early growth in primary skid trails were adversely affected by compaction. He suggested discing or subsoiling to break up the compaction and improve seedling establishment and early growth. Hatchell (1981) tilled and fertilized heavily compacted skid trails and landings and obtained growth of seedlings through age 4, that was close to the growth on undisturbed soil.

The economics of primary skid trail and landings rehabilitation can be approximated using the data of Wert and Thomas (1981). Benefits from skid trail rehabilitation for hardwood, hardwood/pine, and shortleaf pine on site index 70 (base 50 years) land is estimated (Table 2).

Evaluated sawlog rotations of 60 to 70 years were used. Table 2 shows the expected volume of timber per hectare and the value per cubic meter. Wert's and Thomas' (1981) growth loss of 74% was used to predict growth of timber on roads and skid trails. The predictions showed 26% of the timber volume on skid trails as compared to that on undisturbed soil. Growth losses on skid trails ranged between 223 and 311 cubic meters (3,184 and 4,440 cubic feet) for the rotation.

Hatchell (1981) stated that long term growth could not be projected from his 4-year study on the effects of compaction, but the data of Dissmeyer (1985) and Amateis and Burkhart (1985), on early (5-10 years) height differences between site preparation treatments on upland Coastal Plain and Piedmont sites show that differences persist to the end of pulpwood rotations. The growth curves presented by Dissmeyer (1985) and Amateis and Burkhart (1985) suggest that growth difference would probably also persist through 60-to 70-year sawlog rotations. Hatchell (1981) found that 4-year heights were the same between rehabilitated skid trails and uncompacted soil. Projecting to the end of a pulpwood rotation, the trees in the former skid trails should be about the same as trees growing on the uncompacted soil. For the purposes of this analysis, it was estimated that only 75% of the growth loss would be regained by skid trail rehabilitation.

The average cost to fully treat hectare of skid trail is $900 ($360 per acre). Full treatment includes waterbarring, ripping or discing, seeding, fertilizing, and mulching where needed. The present value of the timber productivity recovered ranges from $1,193 to $4,568 per hectare ($477 to $1,827 per acre). The benefit/cost ratio for hardwood is 1.33, for hardwood/pine - 2.82 and for shortleaf pine - 5.07.

The real rate of return over inflation ranges from 2.4 to 4.8%. The real rate of return of 2.4% for hardwood is comparable to low risk investments in government securities. The return of 3.8% for hardwood/pine is comparable to investments from low to medium risk income/growth mutual funds. The 4.8% return for shortleaf pine is comparable to returns from medium risk income/-growth mutual funds.

Table 3. Analysis of economic benefits of watershed treatments associated with roads.

	Treatment 1/		
	Seed Without Mulch	Seed With Mulch	Hydroseed & Mulch
Cost per kilometer - $	356	569	701
Cost per kilometer for soil and water technical services - $	62	62	62
Total cost of watershed treatment - $	418	631	763
Benefits			
Savings in construction costs - $/Km	311	311	311
Savings in annual maintenance costs - $/Km	186	186	186
Benefit/cost (10-year period)	4.4:1	2.9:1	2.4:1

1/ Treatments included fertilization and liming where needed.

It appears from this analysis that investment in skid trail rehabilitation will reduce sediment yields and benefit fisheries, and will also benefit landowners economically. The more valuable the timber product grown, the greater is the return on the investment. Investment in maintaining soil productivity can be as good as investments in some other long term options.

Roads can be a major source of erosion and sediment and rehabilitation appears to be economically justifiable. Reducing erosion and sediment from roads includes proper location, drainage, surfacing and revegetating cut and fill slopes. During a planning analysis, Jim Maxwell 2/ and engineers on the Chattahoochee-Oconee National Forest found the inclusion of soil and water resource management in the location and construction of forest roads results in an estimated $311 per kilometer ($500 per mile) savings in construction costs and an estimated annual savings of $186 per kilometer ($300 per mile) maintenance costs (Table 3). These savings in construction costs come from avoiding problem soils, wet areas, and unstable slopes. Maintenance savings are derived from the revegetated cut and fill slopes, which reduced erosion from these sources and prolonged the time needed for ditch lines to fill with sediment. Without revegetating cut and fill slopes, ditch lines need to be reconstructed one or more times a year. Vegetated fill slopes are more stable and less likely to erode or slump, thus fill slope maintenance costs are reduced. Also, proper spacing of road drainage decreases ditch and surface erosion.

The costs of revegetating cut and fill slopes ranges from $356 to $701 per kilometer ($573 to $1,128 per mile) depending on the amount of cut and fill area per mile and the type of treatment needed (Table 3). The costs of preparing soil and water prescriptions, soils data, and reviewing the project in the field is approximately $62 per kilometer ($100 per mile).

The benefit to cost analysis of rehabilitating cut and fill slopes was limited in my analysis (Table 3) to a 10-year period. For a seed without mulch treatment of cut and fill slopes, the benefit/cost ratio is 4.4. For seeding with mulch, the ratio is 2.9. The B/C ratio for hydroseeding is 2.4. Therefore, the analysis clearly shows that it is to the landowner's financial benefit to invest in soil and water consultation, and in revegetating cut and fill slopes on permanent access roads.

CONCLUSIONS

The control of sediment that adversely affects fisheries is best controlled at its source. Controlling erosion and sediment at its source in forestry, generally means in site preparation areas, logging areas, and roads. Erosion control at these sources can mean significant economic benefit to the landowner through reduced road construction and maintenance costs, savings in site preparation costs, by increased timber production and larger returns on investments. Water quality and fisheries will also benefit. Proper soil and water resource management is good for the upstream landowner, to the downstream fishery and water user, and to society in general. Soil and water conservation is not just a "nice thing to do", but makes good economic sense in forestry.

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Pine Plantations As Wildlife Habitat: A Perspective

A. Sydney Johnson

Abstract. -- Pine (Pinus spp.) forests in various stages of succession provide important seasonal habitat for many wildlife species, and open, frequently burned pine forests are crucial habitat for some species. But extensive unbroken tracts of pure pine are not good habitat for wildlife in general. Historical evidence indicates that the great abundance of wildlife in precolonial southern forests resulted from a mixture of forest types with abundant old growth and substantial areas of openings and early successional forests interspersed. Extensive pine barrens supported relatively little wildlife. On pine sites the diversity of age classes provided by modern even-age forest management can provide good habitat for more vertebrate species than some of the original pine forests, but much depends upon how forests are managed. Hardwoods are essential for most wildlife species. The conversion and attempted conversion of hardwood sites to pine often has been counter to wildlife interests, but the current trend toward less intensive timber management on marginal sites probably is beneficial. The vagaries of economics will determine the place of wildlife in southern forests. In recent years the economic position of game animals relative to timber has improved and may provide additional incentive for incorporating wildlife enhancement measures into forest management plans.

INTRODUCTION

There has been much research on wildlife responses to intensive forest management and it has been summarized and interpreted, frequently, in review articles (Speake 1970, Perkins 1974, Johnson et al. 1974, Harris and Smith 1978, Harris and Skoog 1980, Dickson 1981). Yet pine plantations continue to be discussed with strong opinions often based on inadequate information. Some writers (e.g. Wheeler 1970) contend that the diversity of age classes provided by intensive forest management results in more game animals than when the Indians were here; others (e.g. Margolin 1970) maintain that pine plantations are "biological deserts.".

Evidence discussed in this paper indicates that wildlife was very abundant over most of the Southeast "when the Indians were here"--not because the region was unbroken virgin forest, but because there was great diversity, and disturbance was frequent and extensive. Even then, however, there were areas of pure pine forest that were regarded as "barrens" or "desert." Then, as now, open pine stands that were frequently burned were important habitat for some wildlife species, but fully stocked pine stands after crown closure were not good wildlife habitat. Thus, the "biological desert" paradigm often fits individual pine stands after crown closure. However, before crown closure, pine stands provide excellent year-round or seasonal habitat for a variety of wildlife species. The specific wildlife values of young pine stands change rapidly. Therefore, if stands of different ages are interspersed and key areas of hardwood are maintained, pine forests can be good wildlife habitat, and timber and wildlife management can be effectively and economically coordinated. The discussion that follows develops these points more fully. I thank P. E. Hale, J. L. Landers, and J. M. Wentworth for reviewing the manuscript and providing helpful suggestions.

THE ORIGINAL FORESTS

Most foresters and wildlife biologists assume that managed lands are more productive than unmanaged or wild lands. And, knowing that most wildlife species are favored by early stages of forest succession, many readily accept the conclusion that today's managed forests have more wildlife than those first encountered here by Europeans (e.g. McGinnes and Reeves 1958, Elder

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1965, Newsom 1969, Wheeler 1970). This conclusion is supported by accounts of the scarcity of game encountered by the Lewis and Clark Expedition (Thwaites 1959) and certain other explorers in the northwestern part of the continent. However, for most of the eastern part of the continent, even a superficial review of historical literature will raise doubt about this conclusion. Early travelers obviously were awed by the abundance and variety of wildlife and, although some early writers are known to have exaggerated, there are so many similar reports that they cannot be dismissed. Many of these statements have been extracted and compiled for wild turkeys (Meleagris gallopavo) (Wright 1915) and white-tailed deer (Odocoileus virginianus) (McCabe and McCabe 1984).

In addition to narratives, there are market and export records for skins and other commodities. Except for fish, the white-tailed deer was the most important animal food of Indians in the eastern states, and deer hides were important commercial items. Therefore, a good record exists from which to judge its numbers. McCabe and McCabe (1984:29) estimated that precolonial Indians in what is now Canada and the United States consumed 4.6 to 6.4 million deer per year--about twice the number harvested in the two countries in 1982 (3.0 million--Stransky 1984: 739). Yet, the age structure of the harvest as determined from deer jawbones from Indian middens, indicates that a low percentage of the population was being harvested (McGinnes and Reeves 1958:9 and Elder 1965).

In the late 1600's to the mid-1700's deer hides became the most important export item from the Southeast, and the rate of harvest greatly increased. The number of hides exported from Charleston, South Carolina, averaged 151,000 per year from 1739 to 1765 (McCabe and McCabe 1984: 26). These exports are in addition to deer hides used domestically by Indians and white colonists and probably do not even include all deer exported from South Carolina. Nevertheless, the average annual export was almost three times the number of deer harvested in the state in 1982 (54,321--Stransky 1984:739). Similar numbers of deer hides were shipped from ports in Georgia and the Pensacola Florida-Mobile Alabama area, and smaller numbers were shipped from other ports in these states (Young 1956:23; Wing 1965; McCabe and McCabe 1984:26). These harvest rates were sustained for decades before deer populations diminished under the intense hunting pressure and the increasing impact of white settlers. Narrative accounts and other information indicate that other game species also were present in much greater numbers than today.

Of course there was much more habitat then, and this partly accounts for the large numbers and great diversity of wildlife. But it is clear that densities of deer, wild turkeys, and other species were very high in some areas. It is instructive for the manager to examine precolonial forest conditions that supported such an abundance of wildlife.

The general composition and nature of the original forests (i.e., those encountered by the earliest European colonists) can be reconstructed from early accounts and statistics (e.g. Nelson 1957, Rostlund 1957), analysis of corner and witness trees in land survey records (Jones and Patton 1966; Rankin and Davis 1971; Plummer 1975; and Delcourt and Delcourt 1974, 1977), and relatively detailed descriptions of remnant forests in the late 1800's and early 1900's (e.g. Ashe 1894; Mohr 1901, Dunston 1910, Harper 1914, 1920, 1943). It is clear from these sources of information that, with some definite exceptions, the original forests of the Southeast were very diverse, with distinct forest types that were closely related to soil types.

The Piedmont forests, like those of the Blue Ridge, Ridge and Valley, and Plateau regions, were mixed forests with a preponderance (53%) of oak (Quercus spp.). The red soils, which occupied 35-40% of the Piedmont, supported very little pine. Gray, sandy soils supported mixed pine-hardwood forests, and only about 15% of the Piedmont was predominantly pine (Nelson 1957, Plummer 1975).

Coastal Plain forest conditions were determined mainly by topography and soils interacting with fire. Pine forests were extensive. Sandy, infertile uplands supported forests of almost pure longleaf pine (Pinus palustris). Hardwoods were excluded by soil characteristics and frequent fire. In many areas pines were widely spaced and early accounts refer to extensive pine savannas (Plummer 1975), but some of the pine forests were described as very dense (Lane 1973:148, 156). Where soils contained more clay, hardwoods, especially oaks, were interspersed among the pines and often dominated. Moist, fertile sites protected from fire often supported magnolia (Magnolia grandiflora), beech (Fagus grandifolia), and other mesic hardwoods, especially in the Gulf Coastal Plain (Delcourt and Delcourt 1974, 1977). About one-third of the Black Belt was patches of prairie or savanna (≤10 trees/acre) on alkaline soils, and the forests, which occurred on the acidic soils, were only 5-10% pine (Jones and Patton 1966, Rankin and Davis 1971). In Georgia about one-third of the Lower Coastal Plain was hardwood, gum-cypress (Nyssa-Taxodium), or cane (Arundinaria gigantea) swamp (Bartram 1792:28, Lane 1973:52). Along the slopes between the swamps and the pine uplands, forests graded from hardwood to pine-hardwood to pine. A band of live oak (Q. virginiana) forest extended inland a short distance from the coast (Plummer 1975). In the Carolinas, bays and pocosins supporting hardwood-cypress swamp, shrub bog, or wet prairie added other elements of diversity.

The old growth forests must have produced mast in quantities difficult to imagine today, and the abundance of acorns and chestnuts (Castanea dentata), clearly were important in supporting dense populations of turkeys, deer, passenger pigeons (Ectopistes migratorius), and other species. But, over the Southeast as a whole, unbroken expanses of even-aged old growth forest were much less common than generally imagined.

Indians were the major factor affecting the forests, although lightning, wind, and ice storms--often followed by fire--were also significant forces of disturbance. Indians practiced agriculture extensively, clearing land by girdling trees and burning (Swanton 1946:304-310). Some areas near large towns were farmed continuously, but many fields were cropped for only a few seasons then abandoned for new clearings. Some of the abandoned fields became grasslands maintained by repeated burning. Rostlund (1957) made an extensive review of accounts of precolonial vegetation in the Southeast and concluded that prairies and savannas made up a considerable part of the region. He quoted references to grasslands and cultivated fields in nearly every state and physiographic province from Virginia to the Mississippi River. Some referred to grasslands or savannas extending for miles. The Indian population over much of the Southeast was drastically reduced between 1560 and 1700 (Swanton 1946:11-21), and some of the dense pine forests described later may have been established on abandoned Indian fields.

The diverse pattern of vegetation that has been reconstructed is consistent with the the accounts of abundant wildlife. The intermingling of mature forests, deadened timber, savannas, grasslands, and agricultural fields provided near optimum conditions for wildlife. The Indians, probably unintentionally, practiced far better wildlife habitat management than managers can affort to today.

However, wildlife was not uniformly abundant. Although early writers seldom provided enough detail for comparison of wildlife abundance in specific habitats, descriptions of extensive "pine barrens" in parts of the Coastal Plain contrast sharply with the often poetic descriptions of the more diverse forests on better soils.

For example, John Davis, travelling through an "endless track of pines," between Charleston and Georgetown, South Carolina about 1800, wrote of the "awful solitude of the woods ... heard no sound but that of a woodpecker" (Cheney 1910:138-139).

Several English travellers wrote of a stage route along the fall line across Georgia before 1830. John Melish in 1806 described the route about 25 miles south of Augusta, Georgia, as "completely barren, and covered with pine trees ..." He was one of several travellers to use the term "desert" (Lane 1973:21, 26). Adam Hodgson, at Macon in 1820, wrote " ... from the fort the eye looks down on an unbroken mass of pine woods, which lose themselves on every side in the horizon about twenty miles distant" (Lane 1973: 57). And Basil Hall, writing about the area southeast of Macon in 1828, said "When one gets into an American pine barren, it looks as if it would never end" (Lane 1973:78).

James Silk Buckingham travelled this route from Augusta to Columbus, in 1828. Between Warrenton and Sparta, "our road lay almost wholly through dense pine-forests, and the constant succession of these trees, with scarcely any other variety, made the way gloomy and monotonous." Just west of Macon: " ... a dense forest of pine-trees, the aspect of which was gloomy and monotonous in the extreme." And, still farther west, "in the woods, the turtle-dove was the only bird we saw in any numbers; a solitary mocking-bird was occasionally seen; but though it was now (early spring), we were never once cheered, in all our journey, by the sounds of the feathered choir, that make the woods of 'merry England' redolent of song" (Lane 1973: 148, 156, 157).

These descriptions of some of the pine forests encountered by early settlers are strikingly similar to those used by today's critics of extensive pine plantations. Plummer's (1975) analysis of original land survey records showed that the true pine flatwoods (southeastern Georgia) had very few tree species. The forest he described would have had little midstory or woody understory and little mast production. These conditions were favorable for a relatively few wildlife species. Outside the coastal flatwoods and sandhills, especially on the Gulf slope, pine forests were more diverse (Plummer 1975) and probably supported much more wildlife. Although deer, bear (Ursus americanus), and wild turkey used the pine forests and were abundant in at least parts of the pine region, they seem to have been associated with the hardwood swamps that dissected much of the area. For example, most early references to wild turkeys that mentioned food or habitat conditions referred to oaks, acorns, or clearings (Wright 1915).

However, it is important to recognize that frequently burned, open, mature pine forests were then, and are today, crucial habitat for some species. These include endangered and other nongame species of special interest--such as the red-cockaded woodpecker (Picoides borealis, Hooper et al. 1980), gopher-tortoise and eastern indigo snake (Gopherus polyphemus and Drymarchon corais couperi, Landers and Speake 1980)--and important game species, such as the bobwhite quail (Colinus virginianus, Landers 1981).

TODAY'S NATURAL FORESTS

The original forests were cleared rapidly as agricultural settlement swept through the South in the early 1800's; the last remnants were cut from 1880 to 1920. In most places original forest conditions cannot be restored-- soils have been modified, the equilibrium of species has been upset, and important species have been lost. Today's "natural" forests--those that regenerated naturally on cutover lands and lands abandoned from agriculture, 1865-1950--differ substantially from those they replaced. Because they regenerated following severe and extensive disturbance (agriculture or clearcutting), today's natural stands are more nearly even-aged and, of course, much younger than the original forests. Those on abandoned agricultural fields usually have little woody understory.

In the Piedmont, soil-disturbance and lowered site quality resulting from erosion have allowed loblolly pine (*Pinus taeda*) to become dominant on sites formerly occupied by hardwood or mixed stands, and on most pine sites loblolly pine has displaced shortleaf pine (*P. echinata*). Conversely, in much of the Coastal Plain agricultural fertilization and fire exclusion have allowed hardwoods and slash pine (*P. elliottii*) to invade sites originally occupied by longleaf pine. Unfortunately, much of the hardwood invading the pine type is of relatively little value to wildlife because it consists of species such as sweetgum (*Liquidambar styraciflua*). And without selective thinning or burning or both, even desirable species usually remain suppressed in the understory and contribute little mast, browse, or cavities. But, where wildlife is a major objective in management, as on some public lands and game plantations, naturally regenerated pine forests managed on a long rotation with frequent prescribed burning are near optimum habitat for many species.

Naturally regenerated pine stands are still common on private nonindustrial lands and on public lands, but on most forest industry lands they have been replaced by plantations.

PINE PLANTATIONS

Plantations differ from today's natural stands in several respects. Whereas many natural stands regenerated following high-grade logging, most plantations follow agriculture or intensive mechanical site preparation and have less residual hardwood rootstock. In some areas drainage and other site preparation allows conversion of cypress or hardwood sites to pine sites. Pine plantations are more uniform in species composition, spacing, and age than are natural stands, and they are usually managed on a short rotation. Generally, these differences would have to be regarded as unfavorable to wildlife. But, it would be too simplistic to conclude that natural stands are always better wildlife habitat.

Because plantation establishment replaces one type of habitat with a very different one, it is difficult to compare plantations with natural stands without carefully replicated experimental studies over a long period of time. Thus, most published studies have compared plantations with natural stands of different and highly variable species composition and generally of different age (Harris et al. 1974, Noble and Hamilton 1975, Dickson and Segelquist 1979, Hurst and Warren 1980, Repenning and Labisky 1985). As would be expected, these studies usually show substantially different wildlife values for the different habitats. However, on wet flatwoods sites naturally occupied by slash pine and unfavorable for growth of most hardwoods, natural and planted stands are more similar in species composition than on other sites. On such an area in southeastern Georgia, Johnson and Landers (1982 and unpublished) compared midsummer bird populations, small mammals, and certain vegetational characters in 40 slash pine plantations 11 to 28 years old and an equal number of naturally regenerated slash pine stands of the same ages. The naturally regenerated stands were less densely stocked with pines than the plantations, which had 40-60% more trees. Canopy closure occurred later and woody understory cover was about 20% more dense in the naturally regenerated stands. Reflecting the earlier canopy closure of the plantations, density and number of species of summer resident birds were lower in plantations than natural stands at ages 11-15. But, after age 15, despite continued differences in understory and overstory density of the two types of stands, differences in bird populations were not detectable. Trapping success for small mammals was mostly related to local site variation (soil drainage), and differences between natural and planted stands were not evident.

Because plantations are, by definition, managed systems, their wildlife value cannot be assessed without consideration of the management practices applied to them. If optimization of timber management as the sole objective could be realized, most wildlife would be affected adversely and there would be no place for some species. Many of the goals of intensive timber management seem contrary to the goals of wildlife habitat management. For example, wildlife habitat managers usually strive for a diverse overstory, sparsely stocked to allow understory development, and a long rotation with trees old enough to produce good mast crops and form cavities. Commercial timber growers want full site occupancy by the commercially desired species, a short time between investment and return on the investment, high growth and yield rates, and economic efficiency in management. These timber management goals are pursued by full stocking, elimination of competition, short rotations, use of genetically improved strains, fertilization, large management units, mechanization, and a high-density road system. If these goals were fully achieved, the intensively managed forest would indeed be very poor wildlife habitat. This view of pine plantations caused many wildlife biologists during the 1950's and 1960's to dismiss industrial forest lands as hopeless.

In the 1970's several things became evident that caused many biologists to change their views. First, because of various economic and public relations incentives and sometimes personal interests of managers or executives, wildlife often *is* given consideration in the management of industrial forests. Second, even where the goals of timber management are pursued intensively and single-mindedly, they are rarely achieved because of economic, topographic, and environmental limitations. And finally, biologists recognized that the 30,000,000 or so acres of industrial forest land in the Southeast offers a great opportunity to increase wildlife production, hunting, and other wildlife-oriented recreation.

Before crown closure, pine plantations of different ages provide excellent year round habitat for early successional species--such as quail, rabbits (*Sylvilagus floridanus*), small mammals, and their predators--and seasonal habitat for many other species, including important game animals such as deer and turkey. Wildlife use of young pine plantations has been intensively studied and is the subject of many publications (e.g. Brunswig and Johnson 1972, Johnson et al. 1974, Atkeson and Johnson 1979, Landers and Buckner 1979, Buckner and Landers 1980). It is clear from these studies that, by providing a mosaic of different age classes, managed pine forests may support a variety of wildlife species and greater abundance of some species than the original unbroken pine barrens. But a hardwood component must be maintained on hardwood sites for animals, such as gray squirrels (*Sciurus carolinensis*) and many species of wood warblers (Parulidae), that depend on hardwoods and to provide mast, which is important to wild turkeys, deer, bear, raccoons (*Procyon lotor*), and other wildlife.

If wildlife is given consideration in management planning, many wildlife enhancement measures can be incorporated at little cost, especially considering other environmental and public relations benefits and the market potential for wildlife-related recreation. Because of economic factors, the trend in the forest industry at this time is toward less intensive management on marginal sites. Furthermore, the economic position of game species relative to timber production has improved significantly in the last few years. These trends, if they continue, should result in increased opportunities for management of at least some important game species.

Guidelines for coordination of timber and wildlife management in southern forests are already available (Johnson et. al 1974, Harris et. al 1979, Buckner and Landers 1980, Harris and Marion 1982, and Landers 1985), and other papers in this session deal with the economics and application of specific forestry practices. But a few generalizations can be offered.

The most challenging aspect of coordinating short-rotation timber and wildlife management, obviously, is maintenance of areas of mature hardwoods and old-growth pine. Site conversion (e.g. drainage) and streamside management zones are perhaps the most important issues in timber-wildlife coordination. Maintaining units of hardwood and old growth, linked by travel corridors and streamside management zones, is crucial to the wildlife objective. In general it is best to maintain hardwoods in stands on hardwood sites rather than having them dispersed within pine stands.

Wildlife may be most effectively incorporated into timber management by planning the size, shape, and arrangement of stands and scheduling harvest and intermediate treatments for desired wildlife benefits. Ideally, the pattern should be such that all the needs of a species are fulfilled in any area of home range size on the tract. This ideal is rarely achieved; and if a variety of wildlife species are considered, it may be impossible. The goal is best approached by careful juxtaposition of small stands so that diversity and patchiness are maintained. But it is important that critical habitats are connected by corridors and streamside management zones. Otherwise habitats may become fragmented into scattered islands too small to support breeding populations and too isolated for use by other populations. This aspect of management is discussed by Harris and Smith (1978), Buckner and Landers (1980), Harris and Marion (1982), and Harris (1983).

Intensity of management within stands also is an important consideration. Decisions regarding site preparation, planting, and intermediate treatments such as fertilization, chemical weed control, prescribed burning, and thinnings can greatly affect wildlife, and several papers on this program elaborate on certain of these. Others are discussed by Johnson et al. (1974), Buckner and Landers (1980), and Landers (1985). If the wildlife objective is considered in these activities, benefits may be obtained at little or no cost to the timber objective.

Finally, the responses of vegetation and wildlife to silvicultural practices may differ drastically at different places and different times depending upon site characteristics, previous use of the land, and weather conditions. Site is an especially important consideration. Foresters generally are acutely aware of the importance of site in timber management, but they often fail to recognize that site characteristics may dictate different strategies in wildlife habitat management. Some sites seemingly resist management; others respond readily (Johnson et al. 1974, Landers 1985). Johnson et al. (1986) pointed out that in deer management, blanket prescriptions across a variety of sites may benefit deer populations in some areas and have adverse effects in others.

In summary, pine plantations alone can not fully meet the needs of all wildlife species, but they can provide good habitat for many species. Much depends upon how they are managed. The wildlife habitat managers' goal, which must be pursued with an acute awareness of economic reality, is to arrange stands so as to maintain a pattern of high diversity in structure, age, and timber types and to maintain mast-producing hardwoods on hardwood sites to the extent feasible.

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Prescribed Burning for Managing Wildlife in Southeastern Pine Forests

J. Larry Landers

Abstract.--Reports involving today's wildfires or prescribed burns often fail to recognize fire's primal influence on wild animals. There is much ecological evidence that recurring fires have been a long-standing, evolutionary agent of habitat change to which native species are adapted in the Southeast. Wildlife mortality from flames or smoke is generally insignificant in southern forests. Many upland, resident species thrive in herb-shrub stages that occur in post-fire succession beneath pine (*Pinus* spp.) canopies, and these species diminish when hardwood overstories begin to overshade lower plant strata. Wildlife species characteristic of complete hardwood overstories should be maintained on true hardwood sites where fire rarely penetrated naturally. Brushy patches, inclusions of deciduous subcanopies, and groups of large living and dead hardwoods add diversity to open pine forests with grassy-forb groundstories. Interspersion could be enhanced in the short term by spot burning under moist conditions together with protection of selected parcels, but on many sites a hotter fire is needed periodically to refurbish the open pine community. Research is needed to determine the proportion at which habitat components should be placed together to support different wildlife assemblages. Long-term studies of the effects of fire or its exclusion on forest communities would also help land managers choose appropriate burning schedules to reach wildlife objectives.

INTRODUCTION

Ecologists have long recognized that lightning-set fires must have been a recurring force in original forests of the Southeast for at least 8000 years (Harper 1911, Heyward 1939). Thus, there are many examples that show resident wildlife species to be adapted to fire, if not dependent upon it. During most of that period American Indians apparently set fires to drive game as well as to meet other objectives. Natural fire regimes were further altered by settlers--through range burning with livestock grazing, extensive farming, and lumbering--and by subsequent eras of fire protection and modern land uses.

By the time research-based wildlife management emerged in this country (early 1920s) there were no virgin tracts left in the Southeast remote or large enough to experience lightning-set fire at its natural frequency. The historical relationships between fire, natural plant communities, and wildlife niches are essentially unknown. Thus, wildlife management is primarily involved with on-the-ground judgment guided by observations, and the use of prescribed burning to influence wild animal populations is still very much an art.

This report summarizes the effects of fire on selected wildlife species and fire's relation to habitat management in southeastern pine forests. I appreciate the helpful comments on this manuscript by James G. Dickson, Lowell K. Halls, A. Sydney Johnson, Roy Komarek, Brad S. Mueller, and Dan W. Speake.

DIRECT EFFECTS OF FIRE

Some behavioral reactions of vertebrate animals to burning have been summarized in a report pertaining mostly to wildfire (Lyon *et al.* 1978). It has been commonly observed that less mobile species, such as small rodents, are most likely to panic while larger animals usually move calmly during a fire. White-tailed deer

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(*Odocoileus virginianus*) are known to congregate on burned-over range and lick the ash residue, apparently to obtain minerals. Upland game birds, raptors and many smaller birds often are attracted to fire or to the smoking landscape as foraging sites.

Deaths of wild animals are seldom attributed to fire in the Southeast. Apparently, birds rarely succumb to fires (Bendell 1974). Means and Campbell (1981) noted deaths of several glass lizards (*Ophisaurus* spp.) and several diamondback rattlesnakes (*Crotalus adamanteus*) in mid-ecdysis (preshedding stage) at the time of prescribed burning, but they went on to say that very few herps are thus killed in southeastern forests. Similarly, review papers edited by Wood (1981) listed no fire-induced mortality of tree squirrels, furbearers, or black bears (*Ursus americanus*). Hill (1981) reviewed mortalities of rabbits in northern and western habitats caused by wildfires or intense summer burns, but he did not list specific incidents involving southeastern forests. However, after a fast-moving experimental fire through a South Florida prairie, Taylor (1981) recovered carcasses of five marsh rabbits (*Sylvilagus palustris*) on a 20-ha. plot; some degree of susceptibility of this species was noted previously by Komarek (1969). The more widespread cottontail (*S. floridanus*) seems to easily escape flames, as do most of the smaller mammals which inhabit upland sites. The ability of small mammals to go underground or to emigrate apparently accounts for the scant evidence of mortality from heat or suffocating smoke (Taylor 1981).

In a review by Stransky and Harlow (1981) no records of deer death by fire were noted. But recently, Osborne *et al*. (1986) documented numerous deer deaths in a North Carolina pocosin after a wildfire had moved through during a dry period; carcasses were typically found in smoldering hollows within the peat soils. Deer mortality to this extent has not been reported in other southeastern habitat types and most likely did not occur under natural fire regimes.

Indications are that fast-moving burns in habitats of the less mobile species would likely be involved when death results. When mortality does occur, it is usually negligible at the population level (Lyon *et al*. 1978). A proper evaluation should include the effective loss to the population in relation to losses that would have occurred through other causes had the burn not taken place (cf. Cringham 1958). Most undesirable direct effects can be overcome by choosing proper times, places, and methods for prescribed burning.

INDIRECT INFLUENCE OF FIRE

Fire makes its most important impact on wildlife through habitat alteration. There are many variables involving vegetation types, soil properties, topography, animal niches, and characteristics of individual fires that would require species-by-species accounts for thorough discussion. Such detailed analyses are beyond the scope of this report. Therefore, general conclusions of several publications are presented here to form overviews of wildlife groups.

Reptiles and Amphibians

Habitats of herps span the entire moisture gradient from xeric to aquatic. Certain very dry forest types in the southeastern Coastal Plain are inhabited by species which travel in loose sand (sand-swimmers) or live just above sandy substrates. This group depends upon sites open at ground level, particularly those associated with patches of turkey oak (*Quercus laevis*) within longleaf pine (*Pinus palustris*)-wiregrass (*Aristida stricta*) communities or young sand pine (*P. clausa*) stands (Campbell and Christman 1982). Because sand ridges must have periodic fire to keep dense hardwoods from dominating the landscape (Bozeman 1971), reptiles keyed to these open habitats are considered likewise dependent. Another sand ridge reptile, the gopher tortoise (*Gopherus polyphemus*), burrows and nests in sunlit sites and thrives on herbaceous plants that are dependent on frequent fire; several other rare or threatened herps and many common species utilizing tortoise burrows are indirectly benefited by fire (Landers and Speake 1980).

Mesic forests support a less site-specific herpetofauna. For example, Means and Campbell (1981) captured 38 species in a study conducted in northern Florida red hills. Three amphibian and 1 reptile species were predominantly in annually burned pine forests, and 3 amphibians were predominantly in hardwood hammock; the rest were not clearly site specific. These authors also summarized results from a summer burn in longleaf pine flatwoods and from a winter burn in slash pine (*Pinus elliottii*) flatwoods. The overall trap take reached a new high one month post burning on the longleaf site, and the herp species dependent on surface cover did not show a population decline after the burn; 26 species were active throughout the burned area. In the slash pine study there was no noticeable decline in trap take of any species following winter burning.

Very little information is available regarding the more aquatic herps. Those which thrive in or adjacent to sizable water bodies are probably affected very little by fire. The American alligator (*Alligator mississippiensis*) and associated marsh animals benefit from occasional burning of shoreline vegetation (Lyon *et al*. 1978). Species which inhabit small bogs, such as the pine barrens treefrog (*Hyla andersoni*), depend on fires to prevent woody plants from dominating their sites (Means and Moler 1979).

Much more research is needed to clarify relationships between fire and herp species. However, existing data indicate that prescribed burning benefits most species native to southern pine forests (Means and Campbell 1981).

Birds

Fire is one of the most important factors determining the abundance of forest birds. Avian food resources are strongly affected by burning. Total seed production peaks the first growing season after fire and quickly decreases thereafter (Buckner and Landers 1979). Fleshy fruits are severely reduced the first year after a fire except in cases where the more fire-tolerant species such as dogwood (*Cornus florida*) or beautyberry (*Callicarpa americana*) are present. These plants may actually produce more fruits at this time. In open pine flatwoods, fruits of most shrubs peak three to five years thereafter (Johnson and Landers 1978). Understory burning may induce longer-term reduction of most soft mast species on certain upland pine-hardwood sites (Lay 1956).

The litter-dwelling forms of invertebrates eaten by birds are reduced by ground fires in the short term; herbivorous insects quickly increase with the regrowth of succulent plants; and certain species of flies and beetles are drawn to the smoke and heat, or later, to damaged trees (Dickson 1981). These changes may affect reproductive success because arthropods supply critical nutrients for breeding birds.

The physical makeup of bird habitat is also of great importance. Structurally complex areas generally support a greater diversity of birds than uniform habitats, so fire can strongly influence the composition of avian assemblages through its effects on vegetation.

Nongame Forest Birds.--Only general discussions are available on most resident birds in the Southeast. Conner (1981) drew several pertinent conclusions regarding cavity users. He pointed out that woodpeckers and secondary cavity users will decline where fire eliminates snags. Similarly, the ignition of pine gum associated with red-cockaded woodpecker (*Picoides borealis*) cavities can reduce nest sites which are a very limited resource in most of today's forests. Certain foods of woodpeckers can dwindle when fire reduces litter-dwelling insects, deciduous foliage supporting caterpillars, and the availability of acorns and other important fruits. Conner (1981) also listed some potential benefits: new snags are often created by burns, especially in old-growth forests; low, open understories characteristic of burned areas are essential to red-cockaded woodpeckers; production of certain fruits eaten after the breeding season can increase with prescribed burning; many bird species are drawn to residual foods in burned-over areas; and fire provides open feeding grounds where birds capture ants, grasshoppers and spiders. The complexity of the potential negative vs. positive effects on cavity-users points out the need for research on maintaining needed diversity through careful burning techniques.

In a review of songbirds, Dickson (1981) indicated that burning favors the species closely tied to pine stands or early successional vegetation; it selects against those dependent on deciduous canopy foliage, midstory trees, or litter accumulation; and "edge species" may depend on a habitat interface such as occurs at the edge of burns or around hardwood islands within open pine forests.

The fertility of pine sites may have a pronounced influence on bird habitat development. Studies in slash pine stands show that winter burning has little overall effect, apparently because resident birds resume site faithfulness immediately afterwards (Emlen 1970) and because subsequent midstory recovery is too slow to markedly effect bird diversity, at least during 5-year burn intervals (Johnson and Landers 1982). Since warm-season fires formerly entered these poor soil habitats every few years (Wharton 1978) and these fires inhibit hardwoods and shrubs much more than winter burns, it is probable that deciduous canopy birds were originally restricted to wet hardwood drains rather than being common residents of pine stands. This deduction might also apply to the infertile, dry soils of the Coastal Plain where summer fires thoroughly inhibited hardwoods. On the other hand, the mesic clay regions (parts of the Coastal Plain and Piedmont) probably experienced natural fires less frequently and responded quickly after a burn. Bush birds and midstory leaf-gleaners would most likely increase with the rapid post-fire succession. They were probably ephemeral in richer pine forests as well as regular residents of hardwood flats.

Diversity and abundance of birds would be enhanced in areas with a mixture of grasslands and multilayered hardwoods interspersed in open pine forests. These diverse conditions can be achieved by applying fires that result in patchy vegetation (spot burning under moist conditions, etc.) and by sparing selected hardwood areas from fire.

Upland Game Birds.--Habitat requirements of upland game birds have been thoroughly studied but there are still many gaps in knowledge of fire effects. Mourning doves (*Zenaida macroura*) commonly forage on fresh burns (Stoddard 1963a). Such bare areas are particularly important where doves do not have access to the kinds of seeds produced by mechanical soil disturbance. It might be deduced that, before man's influence, the mourning dove had to be a follower of fresh burns because it generally does not scratch in litter for seeds, nor does it alight in dense vegetation when feeding. The tendency for doves to nest in small trees or occasionally in lower plant strata also indicates that periodic fire may have been beneficial in providing early successional stages.

Gallinaceous game birds are affected by fire in several ways. Parasites that infect this bird group are reduced by burning (Stoddard 1931, Metz and Farrier 1971, Ahlgren 1974, Bendell 1974, Jacobson and Hurst 1979). In pine forests, bobwhite (*Colinus virginianus*) and wild turkey (*Meleagris gallopavo*) brood habitat consists primarily of recently burned herbaceous vegetation (Stoddard 1931, Exum 1985).

Cool weather foods of quail and turkey that increase the first year after burning include legumes and certain other large-seeded herbs. Many shrubs and midstory trees will increase fruit production if burned occasionally. Because acorn production declines in many areas with frequent burning, protection of oak patches has been recommended in habitat management of both quail (McRae *et al*. 1979) and turkey (Hurst 1981).

Annual winter burning over most of a management area is essential to maintaining huntable populations of quail in pine forests (Stoddard 1931, Speake 1966). Although responses of turkey populations are less clear, studies of important requirements (plant food diversity, insect production, brood-rearing sites, etc.) indicate that occasional burning is necessary to keep pine-dominated forests from becoming choked with brush (Hurst 1981). Recommendations for habitat maintenance range from burning turkey brood areas at least every other year (Exum 1985) to a general interval of once every three years (Stoddard 1963b). Burning before the nesting season is often recommended, with small, scattered areas burned each year throughout winter for regular production of greenery (Stoddard 1963b) and others every 2-4 years to insure some fruit production (Speake *et al*. 1975).

Ruffed grouse (*Bonasa umbellus*) select herbaceous habitats for brood rearing (Harris 1981). One of the major winter forages (*Kalmia latifolia*) of grouse in the Southeast has been shown to increase in crude protein and phosphorus with burning (Thackston *et al*. 1982). This game bird is considered a fire climax species, or at least one that benefits from recurring fires (Sharp 1970).

Birds of Prey.--Predatory birds are indirectly affected through fire's influence on nesting sites and food supplies. Red-tailed hawks (*Buteo jamaicensis*) have been recorded feeding on grasshoppers fleeing from fires. Kestrels (*Falco sparverius*) and many other hawks and owls also are attracted to burns in search of prey (Stoddard 1963a, Komarek 1969).

An important factor in the ecology of most predatory birds is the population level of prey species. Most hawks and owls depend on the cotton rat (*Sigmodon hispidus*) and cottontail rabbit and other major prey species (herps, large insects, etc.) that are affected by any disturbance that changes the balance between understory cover and forage. Since regular burning keeps habitat in a suitable condition for the more common mammals but temporarily exposes them when cover is ignited, and since thickets retard the efficiency of predators, it is probable that fire benefits avian predators through availability of food (see *Mammal* section). The maintenance of prey populations for golden eagles (*Aquila chrysaetos*) is an objective of burning mountain balds in the Southeast.

Cooper's and sharp-shinned hawks (*Accipiter cooperii* and *A. striatus*) seem to key in on quail and the larger or more colorful passerines. These "blue darter" hawks are primary predators of such birds that are abundant in fire-maintained game lands in the Deep South.

Because hawks nest mainly in living hardwoods and the more widespread owl species nest in tree cavities, fire has the potential to adversely affect reproduction if it is intense enough to destroy nest trees. Light winter burning probably does no substantial harm.

The burrowing owl (*Athene cunicularia*) inhabits sand hills in southern Florida. Periodic fire is important in keeping the substrate open for burrowing, as well as maintaining early successional stages for the herp-mammal food base on which this owl depends.

Mammals

A variety of mammals inhabit each stage of understory and subcanopy development in southern pine forests. No single species satisfies all of its seasonal needs in any one uniform stage. Rather, their dietary and structural requirements are partially in opposition because of competition for sunlight within a stratum and progressive dominance of taller strata over shorter ones. Therefore, some degree of habitat patchiness is essential to all mammal species; the acceptable scale of this patchiness is related to the home range size of the species under consideration.

Small mammals.--Of the 44 species of small mammals in the southeastern states, only 16 had been mentioned in research reports when Taylor (1981) reviewed the literature regarding fire effects. He concluded that the fulvous harvest mouse (*Reithrodontomys fulvescens*) and cotton mouse (*Peromyscus gossypinus*) showed a consistent population increase following fire; the cotton rat, eastern harvest mouse (*R. humulis*), and round-tailed muskrat (*Neofiber alleni*) showed population decreases; the old-field mouse (*P. polionotus*) and Florida mouse (*P. floridanus*) showed no measurable change; and nine other species were listed under "response unknown."

The problem with deciphering small mammal responses is related to the very short duration of most studies. The previous evaluation was heavily influenced by data from ten studies conducted from 4 to 28 months; one investigation (Layne 1974) was conducted over a three-year period and another (Baker unpubl.) had run for seven years at the time of Taylor's (1981) review. The complete impact of forest burning is difficult to assess because (1) erratic annual population changes can occur independent of habitat conditions, (2) several years are required for significant changes in seral stages, (3) populations can be depressed immediately by a given burn, but increased in the long run, and (4) when regular burning is stopped, populations can increase immediately but become depressed in the long run.

The best available information comes from Baker's (unpublished) study which was conducted in a park-like loblolly (*Pinus taeda*)-shortleaf pine

(*P. echinata*) stand that had been winter-burned annually for decades. Burning ceased in March 1967, and plant succession was allowed to proceed unhindered. A live trap census was begun immediately after the last fire, continued for 12 consecutive years, and initiated again in 1986.

Many least shrews (*Cryptotis parva*), several eastern harvest mice, and a few cotton mice, short-tailed shrews (*Blarina brevicauda*), and golden mice (*Ochrotomys nuttalli*) were recorded on the fresh burn. During the first and second years post-burn, herbivores and granivores became dominant [cotton rats, cotton mice, eastern harvest mice, and house mice (*Mus musculus*)]. Growth of woody cover mixed in with abundant herbs was an important factor in this increase. Shrews (insectivores) apparently declined during this period, then became rare or absent for the next six years.

The early brush stage (years three and four) also supported abundant cotton rats and cotton mice, but eastern harvest mice and house mice did not persist beyond this stage; the more omnivorous and arboreal golden mouse began a marked increase. Golden mice increased further during the next two growing seasons and remained common for at least six years thereafter. Species more fully dependent on groundstory vegetation gradually declined during this period, but the eastern flying squirrel (*Glaucomys volans*) became quite abundant after the ninth growing season. The short-tailed shrew reappeared during years 8 through 11 after fire exclusion, probably as a result of optimal litter structure and arthropod abundance.

Nineteen years after fire was excluded (1986), a few golden mice and many flying squirrels were captured, and gray squirrels (*Sciurus carolinensis*) were often seen (all arboreal species). To date, it appears that the terrestrial species and even the semiarboreal golden mouse depend on early post-fire successional stages in this forest. Whereas Baker's data might apply only to certain pine forests, it serves here to illustrate a basic premise: the majority of small mammals thrive in early- to midsuccessional habitats which are maintained (if not created) by fire, or by some other disturbance that has a similar effect on vegetation. The relationship between sunlight intensity, lower-level vegetation, and small mammal species should be investigated in other forest types to more fully assess the role of fire.

Tree Squirrels.--Burning can have a major impact on tree squirrels. Kirkpatrick and Mosby (1981) pointed out that fire significantly degrades habitat of squirrels when it is employed effectively to maintain pure pine stands. In such cases the most serious negative factor was thought to be the damage to den trees, developing hardwood saplings, and mature mast producers. In contrast, they felt that low-intensity ground fire might have no adverse effects in squirrel woods other than the destruction of acorns in the duff.

Fire may have a positive influence on squirrel habitat in some situations. For example, it is generally accepted that squirrel population levels depend to a large degree on the supply of acorns; low-growing oak species in the Coastal Plain are dependent on periodic fire for maintenance and for acorn production (Williams 1977). Furthermore, squirrels require certain nutrients that are insufficient in acorns (protein, key minerals). For a balanced diet they also feed on mushrooms (which often increase with burning) or fruits and seeds such as dogwood drupes (a species maintained by fire in many forests).

Population data are very scarce for any squirrel species in pine-dominated forests. Least is known about the ecology of southern flying squirrels. In Baker's study (*op. cit.*) this secretive species was not captured frequently in a post-fire study plot until about the tenth year when water oaks (*Quercus nigra*) and other hardwood saplings formed a tall midstory. However, in this same pine forest (Tall Timbers Research Station) flying squirrels are very abundant, even though most of the landscape has been winter-burned annually for over a century. W. Baker (pers. comm.) documented 20 to 30 flying squirrels denning together during winter in a nest box erected in open pine woods. Habitat quality is enhanced by mature live oaks (*Quercus virginiana*) spaced throughout the annually burned property. Also very abundant in this forest are gray squirrels and fox squirrels (*Sciurus niger*).

In frequently burned pine-dominated forests, gray squirrels primarily inhabit drains, wet depressions, and upland hardwood islands which get their start where fire misses areas for a few successive years. These hardwood islands develop less frequently on flat terrain than clay hill terrain. For example, on quail plantations in the Red Hills region of southwest Georgia and northern Florida, the spread of hardwoods is a constant problem where old field loblolly and shortleaf pines predominate. Hardwood encroachment advances as lightning strikes and pine beetles gradually kill the large pines while annual winter fires tend to repress pine regeneration. Fire quickly becomes less effective at controlling hardwoods as pine needle cast decreases. Since practically all pine forests on well-drained clay sites, whether in the Coastal Plain or Piedmont, are old-field communities, it is probable that squirrels will be provided for where winter prescribed burning is the sole tool for controlling hardwoods in such forests. Because gray squirrels feed to a large degree on pine seeds, habitat quality could be more stable with parcels of mixed pine-hardwood than in pure hardwood forests where fluctuating oak mast is the only mainstay. However, in Coastal Plain forests where wiregrass is still abundant in the understory, repeated fires suppress hardwoods so thoroughly that gray squirrels are uncommon.

Fire has probably been a determining factor in the niche separation between gray and fox squirrels in the Coastal Plain. Even though both exist in mixed pine-oak forests and feed heavily on acorns, the more competitive gray squirrel dominates locally where the overlap of oak crowns allows tree-to-tree travel through the canopy. The much smaller body size of grays may also have advantage in contending with low ebbs in acorn supplies.

It has been reported that fox squirrels are more abundant where patches of oaks comprise less than 30% of pine-hardwood stands (Hilliard 1979). From long-term studies in longleaf pine forests, Weigl *et al*. (1983) theorized that southern fox squirrels evolved into the largest sciurid in North America (1 kg or larger) through the advantage of traveling long distances to find longleaf pine cone concentrations and the greater ability to handle and tear apart these large cones. This theory together with the fact that fox squirrels are quite clumsy when trying to travel in canopies, and spend a great deal of time foraging for acorns as well as bulbs, seeds, etc. on the ground, would indicate they do best in fire-type pine forests with scattered hardwood inclusions. A lush, grassy groundstory maintained by fire is important as protective cover from predators (Hilliard 1979). The gradual disappearance of this mixture of habitat components has led to a serious population decline of fox squirrels throughout the South.

Rabbits.--The subject of prescribed fire and rabbits in southern forests was reviewed by Hill (1981). He stated, "Most wildlife researchers believe that any planned fire that reduces plant succession to an earlier stage will generally be beneficial to rabbits." The immediate adverse effects of cover reduction are thought to be overridden by improved forage quality and quantity for two or more growing seasons after burning. Hill (1981) also concluded that burn cycles longer than two-year intervals would be less beneficial, but that "any fire is believed better than fire exclusion."

There are important implications that burning helps reduce the parasite burden on rabbits (Hill 1971; Van Rensburg 1971). By combining the findings that rabbit litter size depends on the nutritional quality of forage (Hill 1972) with the numerous data that show light burning increases high-protein herbs (legumes, grasses, etc.) eaten by rabbits, the potential becomes clear for a positive reproductive response to fire. However, since rabbits also feed on certain shrubs and vines (especially during winter) and require thickets for escaping from their many predatory enemies, it would seem that a clean annual burn would be far less ideal than mosaic burning that would leave sizable patches of woody plants. It is also possible that burning a number of scattered parcels periodically during the colder months might provide greenery that would help overcome food shortages. To maintain habitat diversity, Hill (1981) suggested alternating the burning on adjacent plots during a given year.

Furbearers.--There are eight medium-sized mammals classified as fur bearers that live in southern forests. All are highly mobile, terrestrial species--foxes (*Urocyon cinereoargenteus* and *Vulpes fulva*), bobcat (*Lynx rufus*), raccoon (*Procyon lotor*), skunks (*Spilogale putorius* and *Mephitis mephitis*), opossum (*Didelphis marsupialis*), and coyote (*Canis latrans*). There are apparently no references to indicate any direct effect of fire on these mammals, but indirect effects on foods and other resources can be quite important (Hon 1981).

The welfare of major predators--foxes, bobcat, and coyote--depends to a great degree on accessibility to smaller mammals. The benefits of fire in maintaining early successional habitats for these prey species was discussed in previous sections. It is also probable that predator efficiency is improved by ground fires (open substrates for quieter stalking and easier capture of prey, concentrating effect on prey in patches missed by fire, etc.). If improved efficiency is a significant advantage, it may be that burning annually provides better stalking grounds than biennial or longer intervals that actually yield the most total prey. This factor might account for a dense bobcat population recorded on a quail plantation where winter burning was conducted annually (Miller and Speake 1978). Furthermore, it has been suggested that, under natural conditions, frequent fires worked together with predators in keeping small mammals in normal population bounds (Komarek 1939).

While terrestrial furbearers all eat smaller mammals to some extent, other food items are important to various degrees. Insects are primary or secondary food items. Litter dwellers (certain ground beetles, etc.) are often displaced by herbivorous insects (grasshoppers, etc.) after a fire; the latter insect group typically constitutes the bulk of insect components of furbearer diets.

Fruits are important in diets of the more omnivorous species (foxes, coyotes, raccoons, and opossums). Of the major fruit species, acorns, persimmons (*Diospyros virginianus*), plums and cherries (*Prunus* spp.), and grapes (*Vitis* spp.) can be severely reduced by fire in the short run. However, these woody species require openings for establishment, so edges of burns in pine forests may be common regeneration sites for many of these plants. Important berry producers such as blackberry (*Rubus* spp.), blueberry (*Vaccinium* spp.) and gallberry (*Ilex glabra*) produce the most fruit a few years after fire pruning. Fire at three-year intervals would optimize fruit production in open slash pine forests (Johnson and Landers 1978).

Hon (1981) inferred that burning on a three-year rotation should create desirable furbearer habitat in the southeastern pine region. He also noted that certain fire-sensitive fruit producers should be protected for longer periods. To these suggestions might be added that some upland areas be burned more frequently to maintain grasshoppers, etc. and low vegetation where predators could more efficiently catch prey.

Black Bear.--Black bears ranged throughout the southern pine belt before the build-up of human population centers. Occupied range south of the mountain regions is now restricted to large, relatively inaccessible forests in the Lower Coastal Plain.

Hamilton (1981) synthesized information concerning fire effects based primarily on his bear research in North Carolina and the investigations of other researchers in Florida. He pointed out that periodic winter burning is propitious for production of fruits [dwarf oak, saw palmetto (*Serenoa repens*), etc.] and tender shoots which comprise the bulk of the diet, but advised against summer burning because it can deprive bears of a wide variety of foods. For pocosins, Hamilton (*op. cit.*) suggested that periodic burning (every three to seven years) be restricted to zones between pine-scrub oak sand ridges and Carolina bays or hardwood swamps. Because broad-scale burning temporarily reduces food supplies over large areas and pushes bears into unfamiliar territory where they are quite vulnerable, he recommended burning numerous, small areas throughout bear habitat to create a maze of post-fire stages, and to burn pine-hardwood habitats on a 5-10 year rotation. This recommended frequency might have to be modified depending on soil fertility of a given management area. Planning for juxtaposition of various successional stages seems as appropriate for managing habitat for black bears as it does for the mid-sized omnivores discussed in the previous section. In pocosin country it is critical to schedule prescribed burns when peat soils are saturated to guard against subsurface fire. However, the benefits of careful burning are evident when compared to the destructive nature of wildfires which occasionally ravage through "protected" pocosins.

White-tailed deer.--Most information regarding the effects of fire on deer pertains to habitat influences. Stransky and Harlow (1981) pointed out that burning typically causes several changes: 1) an increase in certain essential nutrients (protein and phosphorus which are generally limiting in the Southeast) and palatability of forage during the first growing season or longer; 2) initial reduction of leafy biomass, followed by effective increases until browse grows beyond a deer's reach (above 1.5 m after about three years); and 3) an initial decrease in fruit yields of most shrubs, followed by increases in the next three to five years in some forests or longer-term decreases in others. The overall higher plane of nutrition resulting from fire can improve antler development in bucks and the condition of fawns (Beasom and Springer 1981).

Negative effects commonly noted by biologists are the reduction of acorns and a temporary dislodging of deer from their home ranges after large-scale fires. Regular burning favors herbs over woody browse plants, more so by warm-season than by winter burns. Some of the highly preferred forage plants are woody vines which are notably pruned back by fire and may be virtually eliminated by repeated burning of areas with dense deer populations. Therefore, the burning interval and percentage of an area burned each year are major considerations in deer range management.

Since browse plants generally surpass their prime by the fifth growing season after sprouting, deer range might approach optimum condition with a five-year cycle scheduled to burn about 20% per year in small parcels. The conflicting requirements of low browse vs. hard mast supplies would suggest that delineating browse production areas apart from major oak stands would benefit deer. Research on the optimum size and shape of burning units would help refine management schemes. Studies are also needed on effects of small, warm-season burns to see if the resulting succulent growth might better meet the nutritional needs of pregnant does and young fawns.

CONCLUSIONS

The complexity of the foregoing summaries show that any generalization about "how fire affects wildlife" would be tenuous at best. Not only is each wildlife species affected differently, each forest type and local habitat situation reacts differently to a given fire. Cumulative information must be interpreted cautiously.

Even though fire is generally an insignificant direct cause of wildlife mortality, it indirectly influences the abundance and species composition of pine forest wildlife through regulation of lesser vegetation. Most residents are early- or midsuccessional species. Habitation in preclimax stages of today actually reflects a primal dependence on fire--the prevailing disturbance force for thousands of years.

Prescribed burning is perhaps the most under-utilized but valuable tool available to wildlife managers. A critical evaluation of burning is needed before its usefulness can be fully realized in even a single-species plan. If the habitat is decadent then fire may provide benefits quickly, but if the habitat is already in prime condition, fire may set back the targeted species, at least in the short term.

Goal-setting is essential in management with fire. An objective of general wildlife diversity is self-conflicting. But because most species require at least some habitat patchiness, this goal might be approached by blending spot burning with parcels spared from fire for various lengths of time, depending on site fertility and vegetation type. Research is needed for developing recommendations for patch size to accommodate different species. In all cases, the quality of pine sites should be taken into consideration because the richer the site, the greater the probability that increasing numbers of hardwoods will reach fire-resistant size and outstrip the control of low-intensity fires.

The opportunity for "natural community stewardship" in southern pine forests has been foregone for several decades. Attempts to duplicate what anyone might visualize as truly natural should be accompanied by plant ecology research involving variable summer fires together with documentation of resulting gains and losses of wildlife. The trade-offs in choosing one goal over another must be evaluated more closely as managers try to provide for wildlife on dwindling forest lands in the future. The easiest goal--featuring deciduous canopy species--can be reached in pine forests after many years of benign neglect unless a wildfire occurs. The wisdom of taking that course should be closely scrutinized by all decision makers involved in conservation. A better approach for accommodating such species would be to manage for hardwood stands on true hardwood sites.

Management with fire will always require on-the-ground judgment and a thorough knowledge of the requirements of targeted wildlife. Long-term studies of fire-community relationships are needed to help land managers choose the proper burning schemes to reach their objectives.

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Herbicides and Wildlife in Southern Forests[1]

William C. McComb[2] and George A. Hurst[3]

Abstract.--A review was conducted of the literature on the direct and indirect effects of herbicide application on forest wildlife. Herbicides vary in toxicity to wildlife, but acute toxicity to most species from most herbicides under normal field conditions is unlikely. Effects on terrestrial vertebrates of repeated applications of herbicides over long time periods or repeated exposure to contaminants of herbicides (such as occurred with dioxin in 2,4,5,-T) is unknown. Herbicide application alters habitat composition and structure thereby resulting in differential response to herbicide-treated stands by terrestrial vertebrates. Application of herbicides in most southern forest situations may result in short-term changes in the abundance of some terrestrial vertebrates. Herbicide use in mature forest for TSI will promote canopy gaps and understory biomass production, while use in young clearcuts will temporarily reduce understory biomass. Published data describing direct effects of herbicide application on wildlife reproduction and survival and on herpetofaunal response to habitat changes are lacking.

INTRODUCTION

Vegetation management using herbicides is widespread in southern pine and hardwood forests. Herbicides are used in pine forests to release pine seedlings from competing hardwood regeneration and to prepare sites for planting. Use in hardwood stands includes timber stand improvement (TSI), right-of-way management and wildlife habitat improvement. During 1975, approximately 11 million kg (25 million lbs) acid equivalent (a.e.) of 2,4-D (mention of trade names does not imply endorsement by the Kentucky and Mississippi Agricultural Experiment Stations) was used in the U.S. in non-agricultural crop situations, including forestry (U.S. Forest Service 1984). The U.S. Forest Service (1984) provided use and application rate information for herbicides used on Forest Service lands in 1981 and 1982. Approximately 100,000 ha (250,000 acres) were treated with approximately 225,000 kg (500,000 lbs) a.e. of 8 herbicides (atrazine, 2,4-D, dalapon, glyphosate, hexazinone, trichlopyr, sulfometuran methyl, and picloram) each year. These herbicides (except atrazine and dalapon) account for approximately 90% of the herbicides used in southern forests (C.S. Metcalfe, pers. comm.); they are applied aerially or broadcast as pellets in most situations except TSI where individual trees or stumps are injected.

Herbicides in an ecosystem can: (1) degrade on site, (2) be transported to a new site and degrade, or (3) bioaccumulate (U.S. Forest Service 1984). Degradation rates for most herbicides have been estimated under a variety of conditions and vary widely on different sites. For instance, picloram has a half-life of approximately 1 month on moist sites and up to 4 years on arid sites. Glyphosate and dalapon are rapidly degraded by soil micro-organisms; 2,4-D has a half-life of 1 month or less but hexazinone has a half-life of from 1 to 6 months (U.S. Forest Service 1984).

Herbicide transport is generally either by wind, water or herbivores. The solubility and persistence of a herbicide in water are critical to toxicological effects on aquatic organisms. There is considerable variation among herbicides in solubility and degradation in water (U.S. Forest Service 1984). Generally, herbicides used in forest management rarely reach high concentrations in aquatic systems.

The degree of bioaccumulation in vertebrates is dependent upon solubility in organic solvents and water, rate of excretion and rate of metabolism. Chemicals vary greatly in their accumulative nature. Herbicides, their metabolites and their contaminants (such as dioxin) probably vary in bioaccumulation capacity.

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HERBICIDE EFFECTS ON WILDLIFE HABITAT IN UPLAND HARDWOODS

Herbicide use indirectly affects two vegetative components of wildlife habitat: composition and structure. These two components are highly interrelated; a change in habitat composition will likely change habitat structure.

Habitat Composition

Some wildlife foods can be adversely affected by herbicide application, and some can be enhanced by it. Hard mast species composition was adversely affected by broadcast application of picloram in upland hardwoods, but soft mast species and browse species composition and dominance increased 4 years after application (McComb and Rumsey 1981). Some plant species were adversely affected by picloram: grasses (Poaceae), New Jersey tea (*Ceanothus americanus*), dwarf cinquefoil (*Potentilla canadensis*), blackgum (*Nyssa sylvatica*), and sassafras (*Sassafras albidum*). Integration of wildlife habitat management into TSI is possible by injection of low quality stems competing for crown space with oaks (*Quercus* spp.), hickories (*Carya* spp.) and other mast-producing species (McComb and Rumsey 1983a). Increased light penetration into the canopy will allow an increase in crown size and hence a greater likelihood of increased mast production (Goodrum et al. 1971). Simultaneously, killing of undesirable trees allows light to strike the forest floor which should stimulate understory production for browse, or (if the canopy gap is large enough) soft mast production by shrubs.

Habitat Structure

Foliage structure will be altered after herbicide application for TSI in three ways: 1) by reducing overstory cover and increasing cover at lower foliage levels over time, 2) by increasing snag (dead tree) availability, and 3) by altering the litter layer on the forest floor. Rate and method of herbicide application will affect stand structure. Heavy broadcast applications in mature hardwoods or tree injection of residuals after clearcutting will result in high snag density (McComb and Rumsey 1981, Dickson et al. 1983), dense understory cover 1 to 4 years after application (McComb and Rumsey 1981), low overstory cover, and rapid decomposition of the leaf litter layer (Gottschalk and Shure 1979). As a result of these structural changes, the forest floor likely will be hotter and drier than untreated sites until understory cover increases the shade. Light applications of broadcast herbicide or TSI likely will result in an increase in foliage height diversity by allowing increased foliage development of subcanopy layers. Effects on the leaf litter layer would be minimal. Snag density would increase and provide foraging substrate for bark-foragers (McPeek 1985). Hardwood snags created by herbicide-injection have shown the potential for being acceptable nest substrates for cavity-nesters (Conner et al. 1983, McComb and Rumsey 1983a, Dickson et al. 1983, and McPeek 1985); herbicide-injected conifers may not be suitable nest substrates for cavity-nesters (Bull and Partridge 1986) but McPeek (1985) reported higher use of herbicide-killed pine snags than of hardwood snags by bark-foraging birds. Longevity of herbicide-created snags is approximately 4 to 8 years for 50% of the snags created (Dickson et al. 1983, McComb and Rumsey 1983a). Although herbicide-created snags in young stands are ephemeral, they are important to bird use of a stand (Warren et al. 1984, Dickson et al. 1983). As snags fall, they become logs that provide habitat for forest floor fauna.

HERBICIDES AND SOUTHERN PINE SILVICULTURE

Herbicide use in southern forests is most frequently in association with production of southern yellow pines (*Pinus* spp.), simply because of the scale of pine management versus hardwood management in the South. Pine plantations are a prevalent and growing habitat type in the South, and herbicides have become an integral part of plantation establishment and management (Miller 1984). Research on several aspects of plantation management have been conducted throughout the South (Harris et al. 1975, Hurst and Warren 1980). However, information on the more recent uses of herbicides in plantation management as they affect wildlife habitat is generally lacking (Morrison and Meslow 1983). Some general and specific results of research being conducted on the lower Coastal Plain of Mississippi and Alabama are presented as indicators of the relationships of herbicides to some wildlife habitat conditions.

Site Preparation: Broadcast Herbicide and Burn

After clearcutting mature forests (often mixed pine-hardwood), pelletized herbicide is applied to kill residual stems. A hot, broadcast burn is then conducted in late summer; pine seedlings are planted the following winter. This new method is similar to the mist-blow (2,4,5,-T), following inject (2,4-D), and burn method.

Conversion of the mature forest to a pine plantation has drastic effects on habitat for some wildlife species such as squirrels (*Sciurus* spp.), but the early successional stage created can represent habitat improvement for other species (Johnson et al. 1974, Buckner and Landers 1980). Hard and soft mast-producing trees are replaced by a herb-dominated (forb, grass, vine, and shrub) community. Soft mast production by *Rubus* spp. increases with plantation age and peaks in 5 years (Campo and Hurst 1980).

The open nature of the first growing season is too harsh for some vertebrates but is excellent for birds such as mourning doves (*Zenaida macroura*) and bobwhite quail (*Colinus virginianus*) that feed on the ground. During the second growing season the vegetation becomes more dense, affording food (forage) and cover for more wildlife species.

Preferred white-tailed deer (*Odocoileus virginianus*) forage (grasses, forbs, vines, and woody plants) averaged 385 kg/ha (350 lbs/ac) in late summer of the first growing season after herbicide treatment (mist-blow and inject) and burning, whereas mature mixed forests averaged only 75 kg/ha (68 lbs/ac) (Hurst and Warren 1981). Deer forage increased to over 550 kg/ha (500 lbs/ac) by year 5 and then declined as canopy closure occurred.

Small mammal populations are generally low in mature, mixed forests but increase in early seral stages on pine plantations. Perkins (1973) found the highest capture/effort index (24.8/100 trap nights) for small mammals (mostly cotton rats [*Sigmodon hispidus*]) on pine plantations prepared by herbicides and fire. Raptors and medium-sized predators (*Lynx rufus*) were observed frequently in these plantations. Small mammal populations declined at canopy closure (5-6 years).

Logging debris, whips, and snags are a major component of herbicide-treated sites; their addition to the structure provided by rapidly growing herbaceous vegetation improves avian habitat. Darden (1980) found herbicide-treated plantations to have greater bird species diversity and higher relative abundance than plantations that were mechanically site prepared. A total of 47 species was observed with 26 nesting in the first year in mist-blown, injected, and burned plantations (Perkins 1973). Warren et al. (1984) reported the highest cavity-nesting bird relative abundance (695/100 ha; 278/100 ac) to be in 4-year-old plantations prepared by herbicides and fire. Snags usually deteriorate within 8 years.

Site Preparation: Mechanical and Herbicide

A relatively new practice is to follow intensive mechanical site preparation with a broadcast aerial application, either preplant or postplant, of hexazinone (0.6-0.9 kg/ha; 0.5-0.8 lb/ac) for competition control. Mechanical site preparation (shear, rake, burn, disk, bed) reduces the hardwood component, and the herbicide temporarily controls grasses, sedges, and broadleaf weeds.

Such intensive mechanical site preparation destroys all potential snags and most logging debris; during the first year's growth there is little vegetative cover, but remaining plants exhibit rapid growth rates because of little or no competition. Burned windrows have luxuriant herbaceous vegetation. The sparsely vegetated plantations are excellent winter habitat for mourning doves, American robins (*Turdus migratorius*), and bobwhite quail because 2 plant species, dove-weed (*Croton capitatus*) and pokeweed (*Phytolacca americana*), are tolerant to the herbicide and produce a large number of seeds and fruit.

Preferred deer forage in late summer of the first growing season averaged only 99 kg/ha (90 lbs/ac) on mechanical and herbicide-treated plots and over 550 kg/ha (500 lbs/ac) on plots with only mechanical site preparation. During the first winter, deer forage averaged only 4.4 kg/ha (4 lbs/ac) on herbicide-treated plots and about 110 kg/ha (100 lbs/ac) on mechanically-treated plots (Copeland 1986, Blake 1986a). Vegetation on the plantations increased markedly during the second growing season with 1,145 kg/ha (1,041 lbs/ac) of deer forage in late summer and 67 kg/ha (61 lbs/ac) in late winter on plots that received both mechanical and herbicide treatments. Deer forage declined the third year but still averaged 582 kg/ha (529 lbs/ac) (Copeland and Hurst 1986).

Habitat conditions for rabbits (*Sylvilagus* spp.) were poor the first year because of the sparsity of vegetation but conditions improved by the second year. Both forage production and lateral and overhead cover greatly increased during the second year (Copeland 1986).

Darden (1980) found that plantations prepared by the intensive mechanical method had the lowest number of bird species and densities. Perkins (1973) reported only 18 species using the comparatively barren conditions during the first year after intensive mechanical site pre-paration (no chemicals). By the third year 27 species were observed.

Site Preparation: Mechanical and Broadcast vs. Banded Herbicide

A modification of the above site preparation method is to aerially broadcast a pelletized herbicide (hexazinone) after intensive mechanical site preparation, or to apply a liquid herbicide (hexazinone), back-pack style, to only the top of the beds (mounds). The latter method is more cost effective and should leave better habitat conditions in young plantations.

Total plant biomass, excluding pine seedling/sapling weight, was significantly lower on broadcast-treated plots and banded plots than on control (no herbicide) plots in the first growing season. Banded plots averaged 450 kg/ha (409 lbs/ac) more biomass than broadcast plots. Preferred deer forage biomass was only slightly higher on banded plots than on broadcast-treated plots. At the end of the second growing season, there was no significant difference in total plant biomass or deer forage between the 2 treatments or the controls. The herbicide had a short-term effect on plant growth (Blake 1986a). The number of plant species on the broadcast-treated plots was about half that found on control plots the first year but equal to control plots the second year (Blake 1986b).

Pine Release: Herbicides

Another major use of herbicides is to release pine saplings from hardwood competition at plantation age 4-8 years. An aerial or ground application is used.

Effects of an aerial application of a herbicide for pine release were studied in west-central Alabama and east-central Mississippi at plantation ages 4 and 5 years, respectively. In each case, significantly more grass, forb, vine, and woody preferred deer forage was found on the treated, than on control plots (922 vs. 609 kg/ha and 965 vs. 519 kg/ha; 838 vs. 554 lbs/ac and 877 vs. 472 lbs/ac). Forbs accounted for 55-63% of the total forage (Hurst and Warren 1986). Killing the hardwood shrubs released forage and seed-producing plants.

Pine plantations in the South are usually dense at age 4-6 years, and the herbicide application may improve cover conditions increasing accessibility to some species. Habitat was improved for ground-feeding birds such as bob-white quail, mourning dove, and wild turkey (*Meleagris gallopavo*). Nesting habitat for birds that nest in low to tall shrubs remained adequate. Releasing pine seedlings will cause the canopy to close and habitat conditions to change rapidly.

Control of competing hardwood shrubs (suckers and sprouts) can also be accomplished by spot spraying or back-pack spraying (foliar) hardwood stems. This technique is used when few hardwood stems exist in plantations. This method will result in some release of herbaceous plants but on a smaller scale than occurs with a total site application. An important feature of the individual stem system is the opportunity for the field crew to selectively leave (not spray) important food plants for wildlife (*Vaccinium* spp., *Callicarpa* spp., *Rhus* spp., *Cornus* spp.).

Timber Stand Improvement (TSI): Herbicides

Herbicides have long been used to kill (inject) undesirable stems or species of trees in a mixed pine-hardwood forest to release the pine component. This practice alters the habitat by reducing or eliminating hard mast (oaks and hickories) and soft mast (*Nyssa* spp., *Diospyros* spp., etc.), by reducing den trees and by altering vegetative structure and diversity. Production of pine seeds, an excellent wildlife food, would probably increase.

The injected trees become snags, providing perches, foraging sites, and cavities for a short time. Fallen trees provide micro-habitats for some ground-dwelling vertebrates. By killing most of the hardwoods, small openings are created and forage production by grasses, forbs, vines, and woody shrubs increases. Fruit production by tall and low shrub species (e.g. *Vaccinium* spp.) and vines (*Lonicera* spp. and *Rubus* spp.) increases. With more vegetation on he forest floor, cover conditions will improve or rabbits and some other mammals.

General Remarks: Herbicides in Pine Plantation Management

Use of herbicides in pine plantation management is but a small part of the overall scheme. Many factors and practices dictate habitat conditions, such as plantation size, shape, and situation (juxtaposition), age class distribution, seedling spacing, and seedling survival. Intermediate silvicultural practices, precommercial and commercial thinning, controlled burning, fertilizing, and pruning greatly affect habitat conditions. Retention of stream-side management zones, hardwood leave strips, and special areas (seeps, bogs, etc.) are major practices.

Use of herbicides to control grass and herbaceous weed competition is increasing, but the effects are temporary. Generally plant biomass, plant species composition, and herbivore forage are equal to control (not-treated) sites by the second growing season after treatment. Use of herbicides to kill competing hardwoods, either as mature trees (TSI) or "brush" in plantations, eliminates the majority of the hard and soft mast producers. However, hardwoods have no "future" in short-rotation plantations; controlled burning will be used frequently to top-kill hardwoods, so hard mast producers will not have an opportunity to produce. The management scheme will be directed to producing forage and soft mast from shrubs and vines. Pine seed production should be quite high in intensively managed plantations grown on sufficiently long rotations.

With or without herbicides, habitat conditions in pine plantations change rapidly. If the herbicides are successful, pine seedling and sapling growth rates are increased and the rotation is shortened, hastening changes in habitat conditions. With faster pine tree growth the manager can begin thinning and burning practices at a younger plantation age to improve habitat conditions for some wildlife species (Owen 1984).

EFFECTS OF HERBICIDE APPLICATION ON MAMMALS

Toxicological information on mammals is, to a large extent, limited to tests conducted on white lab rats (*Rattus norvegicus*) (Table 1). Hudson et al. (1984) summarized toxicological tests on a variety of organisms, but they only included mule deer (*Odocoileus hemoinus*), domestic goat (*Capra hireus*) and domestic ferret (*Mustela putorius*) with rats in their tests on mammals. The only herbicides tested on mule deer were 2,4-D with an LD_{50} of 400-800 mg/kg (N=3), a dose similar to that reported for rats (Table 1), and silvex with an LD_{50} of 400 mg/kg (N=1), less than that reported for rats. Obviously, sample sizes for mule deer are low and extrapolation from one species to another is unwise, but it seems that some herbicides are potentially more toxic to wildlife than others. Toxicity of dalapon and hexazinone to rats is considerably less than the toxicity of 2,4-D and paraquat

Table 1.--Toxicity of selected herbicides to vertebrates

Herbicide	Species (LD_{50};mg/kg)				
	Mallard[1]	Pheasant[1]	Bobwhite[1]	Bluegill[1] (LC_{50},ppm)	Rats[2]
Alachlor (Lasso)[3]	>2,000	-	-	-	
Amitrole (Amizol)	>2,000	5,000	-	300-1200	5,000
Atrazine (AA trex)	>2,000	>2,000	>5,000	6-24	1,750
Balan (Balfin)	>2,000	-	-	-	-
Butylate (Sutan)	>2,000	-	-	-	-
Chloroxuron (Norex)	>2,000	-	-	-	-
Cynazine (Bladex)	>2,400	-	445	-	-
2,4-D	>2,000	472	>5,000	0.6-11	370
Dalapon	>5,000	-	<5,000	105-1,000	5,000-10,000
Dichlobenil (Casoron)	>2,000	1,189	-	6-12	-
Dinoseb (Premerge)	27.0	26.4	-	-	-
Diuron (Diurex)	>2,000	-	-	7-9	-
DNOC (Selinon)	22.7	31.8	-	-	-
Endothall (Des-I-Cate)	229	< 198	-	-	-
Fluometuron (Lanex)	>2,000	-	-	-	-
Fluorodifen (Soyex)	-	>2,000	-	-	-
Glyphosate (Roundup)	>4,000	-	>4,000	2-160	4,300
IPC-400 (Propham)	>2,000	-	-	-	-
Paraquat Dichloride (Weedol)	199	-	-	8-19	150
Picloram (Tordon)	>2,000	>2,000	-	10-30	8,200
Planavin (Nitralin)	>2,000	-	-	-	-
Potassium Azide (Azide)	22.8	15.1	-	-	-
Silvex (Garlon)	>2,000	-	-	0.7-0.9	630-729
Silvisar-510 (Arsan)	>2,400	-	-	-	-
Sodium Arsenite (Kill-All)	323	386	-	21-42	-
2,4,5-T	>2,000	500-1,000	-	8-47	-
TBA (Benzac)	>2,000	1,000	-	-	-
TCDD (Dioxin, contaminant of 2,4,5-T)	0.108	-	.015	-	-
Terbutryn (Igran)	>2,000	>2,000	-	-	-
Trifluralin (Triflurex)	>2,000	>2,000	-	47-70	-
Velpar (Hexazinone)	-	-	2,258	100-500	1,500-5,000

[1] from Hudson et al. (1984), U.S. Forest Service (1984) or Johnson and Finley (1980).
[2] from Walstad and Dost (1984).
[3] alternative common name presented parenthetically.

dichloride to rats. The U.S. Forest Service (1984) estimated dermal exposure of herbicides to deer (Odocoileus spp.) of 0.101 mg/kg and to rabbits of 0.403 mg/kg for each 1.1 kg of active ingredient herbicide applied per ha (1 lb/ac.). At recommended rates of application, no herbicide for which data are presented in Table 1 for rats would reach LD_{50} toxicity levels through dermal exposure.

Herbivores also may be exposed to herbicides by ingestion of herbicide-contaminated plant material. Oral exposure rates of 1.4 and 1.1 mg/kg for each pound (0.45 kg) of active ingredient of herbicide have been calculated for deer and rabbits, respectively (U.S. Forest Service 1984). Even at this rate, it is unlikely that most commonly used herbicides would be toxic to most herbivorous mammals under most circumstances, unless the herbicide bioaccumulates.

Average application rates for commonly used herbicides range from 1.1-5.6 kg/ha (1-5 lbs/acre) active ingredient. It probably would be safer to mammals to use relatively less toxic herbicides such as amitrole, dalapon, picloram and hexazinone than paraquat dichloride or 2,4-D where feasible. Norris (1981) found traces of phenoxy herbicides in some wildlife species (0.01 to 10 mg/kg) exposed to field herbicide application.

Sullivan and Sullivan (1981) concluded that a forest application 2.2 kg/ha (2 lb/acre) of glyphosate in Douglas-fir (Pseudotsuga menziesii) had no adverse effects on reproduction, growth, or survival of deer mice (Peromyscus maniculatus). Johnson and Hansen (1969) reported similar effects of 2,4-D on deer mice. Indirect effects of herbicide application on mammal abundance have been reported in several forest situations. McComb and Rumsey (1982) reported small mammal abundance increasing 100% 4 years following broadcast application of picloram in upland hardwoods, but a 200% increase was recorded on clearcut plots. The addition of logs, stumps and understory cover contributed to the habitat quality of the treated site. Similarly, Kirkland (1978) reported a 100% increase in small mammal abundance 1 year after 2,4,5-T application in Appalachian hardwoods. McCaffery et al. (1981) reported more small mammals from picloram-created clearing edges than in the center of the clearings or in the adjacent woodland in northern hardwoods. Based on these studies it seems that field applications under normal conditions of picloram, 2,4-D or glyphosate improves habitat for most small mammal species for a few years; species adversely affected by treatment are reduced in numbers probably because of habitat changes and not because of herbicide toxicity.

Application of herbicide in a mature stand will likely increase browse availability; application of herbicide in a young stand will reduce browse availability for a few years. Krefting et al. (1956) successfully used herbicides to promote sprouting of mountain maple (Acer spicatum) for deer browse in northern hardwoods. McComb and Rumsey (1981) reported an increase in available browse in upland picloram-treated areas. Hurst and Warren (1980) reported a similar response by some woody plants in 5-year-old pine plantations in Mississippi; but overall, browse availability was reduced on this site by herbicide (2,4,5-T) application. Easley (1977) reported short-term reduction in woody browse for deer following 2,4,5-T application in southern pine plantations.

EFFECTS OF HERBICIDE APPLICATION ON BIRDS

More information is available on toxic effects of various herbicides on birds than on mammals, primarily because of the frequent use of mallard ducks (Anas platyrhynchos) as test subjects (Table 1). Pheasants (Phasianus colchicus) and bobwhite quail also are frequently used in LD_{50} tests. Results for most herbicides tested on all 3 species were consistent, but with some exceptions. Tests of 2,4-D showed higher toxicity on pheasants than on mallards or quail. Cynazine was more toxic to quail than to mallards. Frequently-used herbicides such as atrazine, glyphosate, picloram, hexazinone, and dalapon seemed relatively nontoxic compared with dinoseb, ONOC, and potassium azide. All toxicity tests reported in Table 1 were conducted under laboratory conditions.

Field studies of bird response to herbicide application largely describe bird response to changing habitat suitability. Dickson et al. (1983) compared bird use of clearcuts with and without 2,4-D-created (injected) snags and concluded that these herbicide-created snags increased the diversity and density of birds using the clearcuts. Warren et al. (1984) reached similar conclusions regarding snags created by spraying with 2,4,5-T and by injected 2,4-D amine. McPeek (1985) recorded bark-foraging bird use of picloram-killed snags in mature Appalachian hardwoods, but she did not detect any increase in abundance or diversity of birds on the TSI site. Snags on her site had not decayed to the point of being good nest sites. McComb and Rumsey (1983a) and Conner et al. (1983) indicated that picloram-killed and 2,4-D-killed trees respectively were potential nest sites for cavity nesters, but girdled trees remained standing longer than herbicide-injected trees. Bull and Partridge (1986) reached similar conclusions in western forests. Broadcast picloram herbicide in upland hardwood forests increased winter bird density over untreated mature hardwoods after 4 years (McComb and Rumsey 1983b). Breeding bird diversity was higher on herbicide-treated plots than on untreated hardwood plots, probably in response to increased understory and midstory strata representation after removal of some overstory trees (McComb and Rumsey 1983b). McCaffery et al. (1981) reported similar findings in picloram-created clearings in Wisconsin. Morrison and Meslow (1984a, 1984b) investigated the effects of 2,4-D and glyphosate application on bird use of clearcuts in western forests. In both studies, herbicide altered the habitat structure resulting in short-term changes in use of the area by some bird species. Savidge (1978) and Beaver (1976) reported similar differential responses of bird species to 2,4,5-T application in a Jeffrey pine (Pinus jeffreyi) plantation. We could find no field studies examining the effects of herbicide application on reproductive success and survival of birds.

Little information is available specifically on effects of herbicide application on habitat of game birds. Hurst (1981) discussed the effects of intensive pine plantation management on wild turkey habitat and he concluded that intensive pine management, including use of herbicides, can provide acceptable habitat for turkeys. Use of picloram herbicide to create clearings in mature hardwoods of central Appalachia resulted in ruffed grouse (Bonasa umbellus) use of 4-year-old treated plots (McComb and Rumsey 1983). McCaffery et al. (1981) reported high grouse use of herbicide-created clearings during the fall in Wisconsin. Use of herbicides to create openings in mature forest for grouse would seem to be particularly feasible in the extensive forest and rugged topography of the southern Appalachians.

EFFECTS OF HERBICIDE APPLICATION ON HERPETOFAUNA AND FISH

Toxicity information is largely lacking for herpetofauna. The U.S. Forest Service (1984) summarized LC_{50} tests for a variety of aquatic organisms and reported concentrations of 200-350 ppm 2,4-D resulted in 50% mortality of tadpoles of 3 non-native anurans. Atrazine concentrations of 0.4 to 50 ppm for tadpoles of American toads (*Bufo americanus*), bullfrogs (*Rana catesbiana*), leopard frogs (*R. pipiens*) and pickerel frogs (*R. palustris*) were also reported (U.S. Forest Service 1984). No toxicity data on terrestrial forms could be found.

Indirect effects of herbicide application on herpetofauna would result by changing the forest floor microclimate and altering the availability of food. Most amphibians and many reptiles are moisture sensitive so a decrease in the canopy cover would allow direct sunlight to penetrate to the forest floor thereby modifying the microclimate. Effects of microclimate modification might be offset by increased availability of invertebrate prey. Research is needed to determine the response of herpetofauna to herbicide application.

Johnson and Finley (1980) tested a variety of pesticides for toxicity on fish. Herbicides varied in toxicity to bluegills (*Lepomis macrochirus*) from relatively toxic compounds such as silvex and 2,4-D to relatively non-toxic compounds such as dalapon and amitrole. All studies are laboratory studies and field response of organisms to herbicides could be different. If use of herbicides in silvicultural practices is at or below rates specified as permissable in forest streams (Newton and Norgren 1977), it is unlikely that acute toxicity to most aquatic organisms would result. A review of indirect effects of herbicide application on aquatic organisms is beyond the scope of this paper.

SUMMARY

The effects of herbicide application on wildlife habitat are usually ephemeral. Herbicide use at normal, recommended rates of application would not usually result in acute toxicity of most vertebrates, but herbicides vary considerably in toxicity to birds, mammals, and fish. Effects on terrestrial vertebrates of repeated applications of herbicides over long time periods or repeated exposure to contaminants of herbicides (such as occurred with dioxin in 2,4,5,-T) is unknown. Field studies of herbicide effects on wildlife are generally of indirect rather than direct effects.

Indirect effects of herbicide application on wildlife is through alteration of habitat. Plant species composition in a stand will be altered depending upon the herbicide used and the method of application. Application of herbicides in most southern forest situations may result in short-term changes in the abundance of some terrestrial vertebrates. Herbicide use in mature forest for TSI will promote canopy gaps and understory biomass production, while use in young clearcuts will temporarily reduce understory biomass. Herbicide use in pine stands to control hardwood competition will reduce the tree species richness and alter structure to increase habitat quality for some species while decreasing quality for others.

Additional research should be conducted on herbicide application effects on reproduction and survival of wildlife under field conditions. Research is also needed regarding both direct and indirect effects of herbicide application on herpetofauna.

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Riparian Zones and Wildlife in Southern Forests: the Problem and Squirrel Relationships

James G. Dickson and Jimmy C. Huntley

Abstract.--Mature woody vegetation along intermittent streams is often retained when upland stands are harvested and are planted to pine. These riparian zones bisecting pine plantations reduce non-point pollution and enhance wildlife habitat. Riparian zones are productive of forage and hard and soft mast, provide habitat diversity, function as habitat corridors, and serve as limited mature forest habitat. Studies are underway to assess the relationships of size and composition of riparian zones to populations of deer, squirrels, wild turkeys, fur bearers, small mammals, breeding and wintering birds, and reptiles and amphibians. In eastern Texas, squirrels were abundant in riparian zones wider than 55 m but were rare in riparian zones narrower than 40 m. Studies of the other vertebrate groups continue.

RIPARARIAN ZONES

In the South, many mature pine and mixed pine-hardwood stands are being cut and replaced by pine (Pinus spp.) plantations. In 1986, 9% of all midsouth timberland is planted pine, up from 6% 8 years ago, and this does not include stands planted to pine but dominated by hardwoods (Birdsey and McWilliams 1986). A large variety and quantity of herbaceous and woody vegetation and fruit in young pine plantations make them good habitat for many species of wildlife. White-tailed deer (Odocoileus virginianus), cotton rats (Sigmodon hispidus), cottontail rabbits (Sylvilagus floridanus), and many birds fare well in young clearcuts. But wildlife habitat for most species deteriorates after 7 to 10 years when pine canopies close and shade out understories of non-pine vegetation.

When timber is harvested, mature forest vegetation along permanent and intermittent streams bisecting upland sites may be retained to reduce soil erosion and to enhance wildlife habitat. These areas of hardwood or mixed pine-hardwoods, called stringers, streamers, streamside management zones, or riparian zones (RZ), throughout pine plantations create habitat diversity and edge, which are important to many species of wildlife. They serve as travel corridors for animals between mature stands and can help maintain genetic flow between potentially isolated populations in adjacent mature stands, thereby helping to maintain population genetic viability. The zones also provide limited habitat for species associated with mature forests, such as pileated woodpeckers and large carnivores. Nesting sites, food, and cover probably are increased for many species of wildlife. Hard and soft mast are produced by the residual trees, and nesting and foraging sites are available in the shrub and canopy vegetation. In Mississippi (Warren and Hurst 1980) and in eastern Texas (McElfresh et al. 1980), squirrel (Sciurus spp.) use of RZ was much higher than in adjacent upland stands. Hardwood drains along intermittent streams in RZ usually have fertile soils that support a luxuriant growth of vegetation, producing high yields of a variety of forage and mast and also providing escape cover for deer (Halls 1973). Studies have shown that floodplain forests downstream from RZ support more birds than upland pine stands (Dickson 1978, Stauffer and Best 1980), probably due to their greater vegetative structural diversity. There are also a large variety and an abundance of birds along forest edge (Strelke and Dickson 1980). Retention of mature vegetation along permanent and intermittent streams in clearcuts has been recommended for deer, wild turkeys (Meleagris gallopavo), squirrels, and song birds. In the South, the retention of RZ in clearcuts is policy for the USDA Forest Service and several large industrial forest landowners.

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THE PROBLEM

Quantitative data on effects of RZ on wildlife populations are insufficient to enable wildlife managers to justify the retention of RZ in land-use plans on a biological and economical basis. For informed decisions, landowners need to know--What are the differences in wildlife populations in areas with RZ and areas without RZ, and what are the relationships of RZ width and vegetative composition to wildlife abundance? The Wildlife Habitat Laboratory, Southern Forest Experiment Station, USDA Forest Service, is conducting research to help answer these questions by assessing the impact of presence, vegetative composition, and extent of RZ on various segments of the wildlife community. The purpose of this paper is to provide a background on the nature of RZ in the southern forests, discuss the approach and techniques for our research, and present current information on the squirrel phase of the study.

STUDY AREAS AND METHODS

Nine recent clearcuts in East Texas 2-4 years old and 49 to 121 ha in size were selected for study. Selection of the 9 nine areas was based on similarity of topography, soils, vegetation, and surrounding land use. All areas, which had been previously vegetated by second growth pine-hardwoods, were recently clearcut, mechanically site prepared, planted to loblolly pines (Pinus taeda), and traversed by RZ. Mature pines had been harvested from some of the RZ. All plantations were on upland sites, and RZ were along first-and-second order intermittent streams. Pines were generally 0.5 to 1.5 m high. The plantations were dominated by hardwoods, pines, and other woody and herbaceous vegetation. Oak (Quercus spp.) and sweetgum (Liquidambar styraciflua) sprouts, Callicarpa americana, Rubus spp., and Rhus spp. were abundant. Dominant overstory vegetation in RZ included southern red oak (Q. falcata), white oak (Q. alba), post oak (Q. stellata), sweetgum and American beech (Fagus grandifolia).

Assigned treatments were RZ of 3 widths: narrow (< 25 m wide), medium (30-40 m), and wide (> 50 m). Three replications of each treatment were applied. Four sample transects (200 m each) were established in each of the 9 study areas--2 in each RZ and 2 in each adjoining pine plantation. Along each transect, understory, midstory, and overstory vegetation was sampled from 4 points on each transect. Also hard mast is being sampled from visual estimates in tree canopies, and then adjusted by collection in barrels each fall.

The vertebrate community is being sampled by various means. Deer tracks are being counted on plots in RZ and plantations during the fall and spring. Scent stations baited with bobcat urine and fish oil are used to survey furbearers each fall and winter. Small mammal abundance is being determined from live trapping and marking each winter. Bird censuses from transects during winter and the breeding season are being conducted. Reptiles and amphibians in RZ and on plantation slopes are being surveyed by visual counts, inspection of artificial covers, captures from drift fences and funnel traps, and by intensive searches each spring. Wild turkey use of RZ is being determined supplementally by radio telemetry. The study of squirrels in RZ has been completed and is presented here.

SQUIRRELS

Gray squirrels (Sciurus carolinensis) and fox squirrels (S. niger) are sympatric throughout most of the eastern United States (Hall 1981), but favor different habitat types. In eastern Texas, the fox squirrel is more numerous in upland forests, and the gray squirrel is more numerous in bottomland hardwood forests. Both species occur along small drainages with hardwoods and in eco-tones between bottomland hardwoods and the surrounding pine uplands.

Suitable squirrel habitat is lost when older forests are clearcut and converted to even-age pine plantations. But RZ in clearcuts are beneficial to squirrels. In east-central Mississippi, RZ along permanent streams and varying in width from 40 to 141 m had greater squirrel densities than mature pine-hardwood forests (Warren and Hurst 1980). Gray squirrel density was highest in RZ with an average width of 100 m in bottomland sites. In East Texas, gray squirrels used the RZ that were retained in slash pine (Pinus elliottii) plantations (McElfresh et al. 1980). The Texas researchers suggested that RZ 50 to 100 m wide that connect adjoining bottomland forests should provide adequate habitat for squirrels and that additional research would be needed to refine this estimate of necessary width.

The objective of our study was to determine the effect of RZ width on squirrel abundance. Squirrel abundance was estimated with time-area counts (Goodrum 1940) on 2 replications in 1984 and all 3 replications of treatments in 1985 from observation points at least 100 m apart in each RZ. Observation time at each point was 20 minutes, as recommended by Bouffard and Hein (1978). All counts were completed between 0700 and 1030 hours in mid-to-late September, prior to squirrel hunting season. In each RZ, 3 counts by different observers were conducted from 4 observation points for a total of 12 observation periods. One additional count was taken at the edge of the RZ and adjacent plantation to determine squirrel use of plantations. The number of squirrels seen during these 4 hours of observation for each RZ was used to measure squirrel abundance. Squirrel densities based on average detection distances were not calculated.

Squirrel leaf nests were counted in January-February 1985 for another index of squirrel abundance. In each RZ, all nests that occurred in 2 200 by 80 m transects and that appeared to have been constructed in the prior year were counted.

During both years in the time-area counts, squirrels were observed regularly in wide, very rarely in medium, and never in narrow RZ. In 1984, a total of 12 squirrels were observed on wide, 1 on medium, and 0 on narrow RZ. In 1985, with the sample increased by 50%, there were 12, 0, and 0 squirrels on wide, medium, and narrow RZ respectively (Table 1). Leaf nest density was also much greater in the wide RZ, 55 nests were counted on wide, 7 on medium, and only 1 on narrow RZ. Time-area counts and leaf nest densities indicated that squirrels were permanent residents in only the 3 wide RZ, which averaged 93, 73, and 55 m in width. The 73-m-wide RZ had the greatest squirrel abundance in both years and the greatest density of leaf nests. This RZ also had numerous large American beech and loblolly pine trees, which the 93-m RZ generally lacked. These were prime sources of food and cavity and leaf nest sites, and may have accounted for the higher squirrel numbers than in the wider RZ. The minimum width of RZ that will maintain squirrel populations appears to be about 55 m. Fewer squirrels were observed in the 55 m RZ than in the other 2 wider RZ. RZ narrower than about 55-m do not support permanent resident populations of squirrels. There was only light squirrel use in the medium RZ of 30 to 40 m width. Only 1 squirrel was detected during the survey, there were only 7 nests in 1,200 m of RZ, and signs of squirrel feeding were sparse. No squirrels, 1 nest, and no signs of squirrel feeding were observed in narrow RZ.

Only 3 squirrels were seen from the plantation edge points; all of these were in RZ, and no squirrels were detected in the 2-4 year-old plantations.

Both fox and gray squirrels were observed in the time-area counts in RZ. Mostly gray squirrels were detected in 2 of the wide areas and fox squirrels were predominant in the other. Data collection, analysis, and writeup continue for the other animal groups.

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Table 1.--Number of squirrels observed during time-area counts and the number of leaf nests in riparian zones of various widths in eastern Texas

Riparian	Sept. 1984[1]		Sept. 1985[1]		
zone width	Total	No./h	Total	No./h	No. of nests[2]
Narrow (<25 m)	0	0	0	0	1
Medium (30-40 m)	1	0.1	0	0	7
Wide (>50 m)	12	1.5	12	1.0	55

[1] Two replications of each width sampled in 1984 (8 hours of observation per treatment), 3 replications in 1985 (12 hours per treatment).

[2] Found along 1,200 m of transect of each treatment, 400-m lengths in each replication in Feb. 1985.

Effects of Forest Practices on Relationships Between Riparian Area and Aquatic Ecosystems

Edwin Miller[1]

Abstract.--Riparian vegetation influences food energy, large organic debris loading, stream temperature, streambank and bed stability, terrestrial to aquatic buffering and streamflow of lower order forest streams. These functional areas are highly interrelated and affect determine aquatic productivity. Opportunities to manage riparian areas to meet timber utilization and aquatic productivity goals are promising. Research is needed in all areas to quantify the relationships and provide guidance for site-specific riparian management.

INTRODUCTION

The management of riparian areas for the protection of aquatic ecosystems has received attention in the forestry community during the past 10 years. Best management practices (BMP's) which include guidelines for streamside management have been developed and implemented either on a regulatory or voluntary basis in most states. Despite the development of riparian BMP's there is very little published information on how the manipulation of riparian vegetation affects aquatic ecosystems (USDA Forest Service and US Environmental Protection Agency 1978). Notable exceptions are in the areas of forest shade influence on stream temperature and riparian management effects on stream productivity in the northwest United States. The objective of this paper is to provide a brief outline of the relationship between riparian and stream communities. This will help foresters better understand the objectives underlying streamside management designs and identify some areas where an improved understanding of riparian influences on stream ecosystems would be helpful in guiding management strategies for riparian areas.

The quality of stream habitat for aquatic organisms is influenced strongly by riparian vegetation (Meehan et al. 1977). In a broad view there are six interrelated functions which the riparian area serves with respect to the aquatic environment: 1. Riparian vegetation provides a portion of the food energy for certain stream organisms; 2. large organic debris, which is an important component of some forest streams, is produced in the riparian area; 3. solar energy is regulated by the vegetation which shades the water surface; 4. the stability of the streambank and flood plain of smaller streams depends largely on riparian vegetation; 5. the streamside zone provides a buffer between the aquatic and terrestrial habitats, and; 6. streamflow is regulated to some extent by the riparian vegetation.

RIPARIAN VEGETATION AND THE STREAM ENVIRONMENT

Food Energy

In forest streams small enough to be completely covered by the forest canopy a large portion of the food base is supplied by the riparian vegetation. Leaves, needles, fruits, twigs, branches, boles, and insects from streamside vegetation may constitute 70-80 percent of the food energy supply to the aquatic system (Hynes 1970). This food is classified as allochthonous, meaning it originates from outside the aquatic ecosystem. With the exception of large woody material, the amounts, types, and timing of allochthonous inputs are seasonally regulated. A large percentage of this coarse organic material is used within the lower order streams by shredding and collecting organisms. Once this material is processed into smaller sizes, it is subsequently flushed and utilized by invertebrate organisms in higher order streams. The balance of food energy in the aquatic ecosystem is produced within the stream in the form of algae or aquatic vascular plants and is classified as autochthonous. This source of organic matter increases and may predominate in streams exposed to direct sunlight.

The utility of organic material to aquatic organisms in the stream depends on the type of material and the retention time in the stream (Meehan et al. 1977). For example, leaves are generally more easily used than wood, and hardwood leaves are generally more palatable and digestible than conifer needles. Easily decomposible materials supply a ready source of energy and nutrients while coarse or refractory materials provide a lower, yet less time-dependent supply of food. Retention time is the length of time material remains within a defined stream section and is therefore available for decomposition or consumption. Retention time is a function of stream morphology.

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Large Organic Debris

Tree boles, large branches, and root wads, classified as large organic debris (LOD), are supplied by riparian vegetation and become an integral part of many forest streams. This material strongly influences the structure (morphology) of small streams by forming pools (Swanson et al. 1976) and retaining or detaining the movement of sediment and gravel (Bilby 1981, Megahan 1982). LOD also increases the retention time of smaller organic material used as a food source (Bilby and Likens 1980), provides cover for fish (Bryant 1983, Sedel et al.1985), and is an important substrate for biological activity (Meehan et al. 1977). A change in stream channel structure and a reduction in habitat diversity can occur when LOD is removed from a section of stream (Bilby 1984b).

Stream Temperature

For stream organisms, temperature is one of the most important ecological factors because basic metabolic processes are temperature dependent (Ruttner 1963). The temperature of stream water also influences its oxygen holding capacity. Temperature can therefore limit the broad geographical distribution as well as the local (within-stream) occurrence of aquatic organisms including fish (Hynes 1970). Tolerances to temperature maximums, minimums, ranges and rates of change are radically different for the various aquatic organisms. The effect of a change in stream temperature regime on individual species can be insignificant or dramatic. Impacts include changes in growth, development, reproduction, and mobility. Because of the interdependence of various species in an ecosystem the disruption of the life cycles of one or a group of species may cause shifts in ecosystem productivity, species diversity, dominant species, or total numbers present. It should be stressed however that ecosystem changes which result from alterations in the stream temperature regime are not uniformily positive or negative but must be evaluated quantitatively and qualitatively in light of stream management objectives.

The primary source of heat for lower order forest streams is direct solar radiation on the water surface, whereas conduction, convection, and evaporation have little influence on stream water temperature (Brown 1969). Shade provided by riparian vegetation plays a key role in the regulation of solar energy inputs and therefore stream temperature. The effect of riparian shade removal on forest stream temperature has been shown in a number of studies across the U.S. (Brown and Krygier 1970, Levno and Rothacher 1967, Meehan 1970, Hewlett and Fortson 1982, and Swift and Messer 1971). Stream shade removal normally results in increased maximum temperatures, a greater diurnal range in temperature, increased rates of change, and, in some cases, reductions in daily minimum temperatures during winter (Swift and Messer 1971). In some situations stream temperatures decline after flowing through shaded reaches. Cooling of heated water is usually the result of cool water contributions from side streams and groundwater, and flow through coarse streambed gravel (Swift and Baker 1973, Bilby 1984a).

Streambank and Bed Stability

Geologic characteristics and processes are dominant factors affecting overall stream morphology. As stream order decreases, however, riparian vegetation is increasingly important in determining the morphology and stability of forest streams (Zimmerman et al. 1967). Vegetative protection of streambanks, and on smaller streams the streambeds, provides for the continued existence of discrete habitat types. Infrequent episodic flood events play a role in reshaping streambanks and beds. Although floods cause periods of instability, they provide for the critical restructuring of habitat and in some systems cause the addition of large organic debris which add to habitat diversity (Ward and Stanford 1983). The banks and beds of headwater forest streams are ready sources of sediment (Swanson and Fredricksen 1982). Riparian vegetation allows for the necessary natural bed and bank erosion processes, but effectively prevents accelerated erosion which would increase suspended loads and provide a continuing source of active bed load materials.

Suspended sediment loads rarely have a direct adverse effect on adult fishes (Wallen 1951) however, the ultimate results of increased suspended loads, although indirect, can be serious. Some examples include reductions in invertebrate abundances, decreased feeding success of sight feeding species, and dislocation and mortality of early life stages. Attributes of the stream such as stream temperature and nutrient levels can also be altered by increased suspended sediment loads. Increased bed loads and/or intrusion of fines into stream gravels can have a major influence on bottom dwelling species causing shifts in numbers, species, and diversity and also have a direct negative effect on the spawning success of salmonids as well as other fish species. There is an extremely wide range in the tolerance of various species to both suspended and bed load sediments precluding any further broad qualitative statements.

Terrestrial/aquatic Buffer

The riparian area acts as a buffer between the terrestrial and the aquatic ecosystems. The regulation and modification of inputs from the terrestrial zone, primarily nutrients and in some cases sediments, are among the buffering functions. Nutrient inputs due to leaf and woody matter addition are of major importance to the stream ecosystem but are considered a part of energy or food inputs discussed earlier. In this case we are considering mechanisms by which nutrient levels are regulated or altered as water passes over and through the flood plain, and situations where the riparian area can act as a filter to limit the inputs of upland sediments to the stream.

The relative importance of the streamside zone as a nutrient and sediment buffer to the aquatic system has not been well established, particularly for smaller forest streams. Wetlands have been studied for use as nutrient removal systems (Bender and Correll 1974, Tilton and Kadlec 1979) and Lowrance et al. (1984) found riparian forests to be an effective nutrient sink. References stating the importance of riparian zones as sediment filters are common (Meehan et al. 1977, van Groenewood 1977), yet reports documenting this function are difficult to find.

Forest systems are generally nutrient conservative and undisturbed forested soils are well protected from erosion. The opportunity or need for riparian areas to regulate nutrient and sediment inputs from the terrestrial portions of forested watersheds are therefore relatively minor. However, the opportunity for the riparian area to serve as a buffer for forest operations activities conducted on the watershed may be significant and is considered later.

Streamflow

Current speed (velocity) and discharge (rate) are important physical attributes of stream systems that have a major influence on the occurrence, distribution and spawning success of aquatic species (Hynes 1970). The relationship between riparian vegetation and the velocity of a stream depends basically on how the vegetation affects the roughness of the channel during low flows and the entire floodway during flood flows. Increased roughness decreases stream velocity whereas decreasing channel and flood plain roughness increases velocity (Gray and Wigham 1970).

The influence of riparian vegetation on stream discharge is not clear, however, increased annual stream discharge due to riparian clearing has been reported (Dunford and Fletcher 1947, Rowe 1963). Where fluctuating discharge or the seasonal drying out of streams eliminates selected or many aquatic species, increases in flow during critical periods may be advantageous, but the overall influence of streamside vegetation would have to be considered in such cases. It would appear that the influence varies from riparian stream systems in dryland or desert environs to those in the humid forest. Investigations have thoroughly demonstrated that forest harvest other than in riparian areas results in increased streamflow (Hewlett 1982) and those increases would seem to overshadow the effect of riparian clearing in humid areas.

MANAGEMENT OF THE RIPARIAN FOREST

Forest management options for the riparian area can range from no activity to complete vegetation removal. The no activity or leave strip option is practiced primarily on public lands where a conservative management perspective is coupled with a strong multiple use directive. On lands where an aggressive forest management program is underway, a balance between the costs and benefits of riparian management and stream habitat protection must be established. At the other extreme are those areas where the landowners goals or attitudes are incompatible with stream habitat protection, the maintenance of riparian values are not considered, and riparian vegetation is abused or eliminated. What are some of the generalized impacts on the six functions for a forest management option which includes the removal of selected timber from the riparian area with careful attention to stream habitat protection?

Food Energy

The basic relationship between food energy sources and the stream ecosystem is reasonably well understood and allows a qualitative assessment of timber harvest from the riparian zone. Removal of streamside vegetation would reduce the amounts of allochthonous material entering the stream, might alter the quality and timing of allochthonous inputs, and would increase the amount of sunlight reaching the stream.

The extent and duration of reductions in allochthonous inputs following riparian timber harvest is highly site specific and

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would depend on factors such as the amount of canopy removed, rates of revegetation and crown expansion, allochthonous inputs from stands outside the riparian area, and upstream allochthonous contributions. For example, if the length of riparian harvest area was short, harvest levels low, and allochthonous contributions from upstream and/or adjacent areas large, total reductions in inputs to a stream segment might be small. Scenerios for large short-term reductions in allochthonous inputs could also be presented. Rapid revegetation or crown expansion following harvest could lead to overall increases in allochthonous inputs in a relatively short period of time following harvest.

Timber utilization and management goals will largely determine the species mix of the residual riparian stand while ecological factors will determine the species mix through the period of revegetation and crown development. The removal of individual trees in proportion to the original stand composition, for example, would initially result in little or no change in residual stand composition, whereas the removal of one or more selected species could change residual stand composition considerably. The impact of altering species on food quality and/or the seasonability of allochthonous inputs and ultimately stream productivity could be positive or negative and would depend on site specific factors.

Finally, increasing sunlight levels to forest streams can increase autochthonous production (Duncan and Brusven 1985a, 1985b) and subsequent increases in invertebrate production have been shown to increase fish production (Murphy and Hall 1981, Hawkins et al. 1983, Bisson and Sedell 1984). Results may vary for streams which are not nutrient or temperature limited, but these examples clearly illustrate that overall productivity is determined in part by the balance of terrestrial organic inputs and aquatic organic matter production. The overall impact of timber removals from the riparian zone on food energy cannot therefore be generally classified as negative and must be evaluated on a site specific basis.

Large Organic Debris

The importance of large organic debris (LOD) to stream systems is recognized, however, little information is available on rates of LOD inputs to streams from natural or disturbed riparian systems, how much LOD is needed to optimize fish or stream productivity or how to manage riparian areas to provide the sizes and types of LOD needed. This is certainly an area of research opportunity.

Webster and Swank (1985) hypothesized the following scenario for LOD inputs following logging. Depending on logging practices, there may be an initial increase in LOD from logging slash. Inputs could remain high for a short period as windthrow, breakage, and rotting residuals fall into stream channels. The second period would be dominated by successional vegetation development and a decrease in LOD inputs would occur. Later, as successional vegetation declines and shade tolerant or climax species prevail, an increase in LOD input would again occur. Finally during the long period of forest maturation, low inputs would prevail until natural mortality of the mature stand occurs.

With intermediate levels of timber removal or a selection management approach in the riparian forest, it would appear drastic shifts in LOD inputs could be avoided. Maintaining all age classes and a mix of species would be a key in such a plan. Where LOD is an important component of the stream channel, cleaning of stream channels following logging should be avoided if possible (Bilby 1984b) as a means to maintain LOD.

Stream Temperature

Research which has identified the relationship between riparian shade and stream temperature has also led to guidelines for shade management on streams where it has been determined water temperatures must be maintained for aquatic habitat protection. Vegetative strips which continue to shade small streams are the most effective means of stream temperature control (Brown 1972). Many factors determine the configuration of riparian shade necessary to control stream temperature. They include the size of the stream, its orientation, surrounding topography, and the species and density of shade vegetation. (Brown 1972) suggests that simply specifying the width of shade strips or the volume of riparian timber to be maintained are not effective ways to provide shade vegetation which meets timber utilization and stream temperature objectives. Determining canopy density and the portion of the canopy which provides stream shade during critical midday hours on individual stream segments is necessary. Individual trees and understory vegetation can then be identified and marked for protection in the process of planning the management of the riparian area. This requires the skill and judgment of the resource manager working on a site specific basis.

Streambank and Bed Stability

The roots and lower stems of both understory and overstory vegetation bind the alluvial sediments of the bed and bank together and act to hold large organic debris in place (Likens and Bilby 1982). Identification of this vegetation is straight forward as it is normally found growing on or directly adjacent to the streambank and within the bed of smaller streams. Removal or destruction of this vegetation reduces the strength of the bed and bank and allows accelerated erosion to occur especially during flood flows. Restabilization of streambanks and beds is normally a long term process in nature which emphasizes the need for uninterrupted streambank protection.

Providing a wide leave strip would normally assure complete bank and bed protection but this may not be necessary in many cases. As with stream temperature, identifying the critical vegetation for protection while providing for some level of timber removal allows for a more equitable balance between timber utilization and stream protection in the riparian zone.

Removal or damage of stream bank vegetation is not the only hazard forestry operations in the riparian area pose to streambank and bed stability. The indiscriminate felling of other riparian timber and adjacent upland timber, mechanized skidding or yarding operations which physically damage streambanks or streambank vegetation, frequent crossing of streams with machinery, and chemical supression of streambank vegetation are direct activities which can be especially destructive. Slash left in the riparian area can cause damage to streambanks and beds by accumulating during floods, damming and rechannelizing flow and initiating erosion processes. Properly managed, however, large slash can enhance stream habitat by enhancing LOD. Conducting management activities in the riparian area then requires site specific planning and training of operators in order to meet timber and stream management objectives.

Terristrial/aquatic Buffer

The natural function of the riparian area as a buffer between the undisturbed terrestrial and aquatic ecosystems may not be as critical to the aquatic ecosystem as food energy, solar energy regulation, or habitat stability. When the terrestrial area is under management, the importance of the riparian area as a buffer increases and logic suggests the more drastic the terrestrial activity the more important the buffer. Supporting a philosophy that the riparian area acts as a buffer or filter may tend to relieve managers from applying silvicultural practices in a way that adequately protects the terrestrial site as well as the stream. Soil erosion, for example, should be kept to a minimum on forested lands in order to maintain site productivity. Even if the riparian area were a perfect sediment filter, the foresters overall goals are not met by allowing soil erosion to occur. There are situations, however, when the buffering capacity of a riparian area or the separation of activities by providing untreated zones adjacent to sensitive sites is of benefit.

Riparian areas should be used as buffers to stream environments when forest chemicals - fertilizers, herbicides, and insecticides - are applied to the watershed. Factors which determine the hazard of any chemical are exposure and toxicity. Non-toxic chemicals pose little threat to organisms and toxic chemicals are no hazard if non-target organisms are not exposed. Exposure depends on the behavior of the chemical, where behavior is defined as: 1. the means of distribution of the chemical; and, 2. the movement and persistence of the chemical in each component of the ecosystem. In an excellent review of the impact of forest chemicals in streams, Norris and Moore (1970) indicate direct application to surface waters (improper distribution) is the major source of aerially applied chemicals in the aquatic environment. Excluding streams from treatment areas by providing untreated buffer strips is an extremely important first step to assure the proper distribution of forest chemicals.

The riparian area can also serve as a buffer from the mechanical activities involved in forest management operations. Exclusion of all mechanical activities in the riparian zone may not be necessary, but special precautions are required to prevent soil disturbance in the flood zone, damage to residual riparian vegetation, and the indiscriminate crossing of streams. Provision of a special streamside management zone emphasizes these special needs.

In some situations riparian areas can act as sediment filters for flow from upslope areas or for road drainage runoff. Miller et al. (1984) and Vowell (1984) reported providing a buffer area, with high infiltration capacity, between road drainage outfalls and adjacent streams, effectively reduced road sediment loads when flow discharges were low and flow was not channelized directly to the streams. The ability of the riparian area to filter sediments will depend largely on the volume and rate of flow entering the area, the sediment load, riparian ground cover, and infiltration conditions. Flow which is channelized when it enters the flood plain is generally channelized directly to the main stream and no opportunity exists to reduce the sediment load. When flow can be delivered to the flood plain at rates which allow dispersion and infiltration, opportunities for sediment filtration increase.

Flow Regulation

Riparian management ranging from no disturbance to moderate levels of overstory removal should have minor impacts on amounts of streamflow and rates of stream discharge in forested watersheds. Short-term increases in groundwater discharge to streams with moderate levels of timber removal might occur during summer low flow periods and potentially benefit aquatic organisms in streams which are flow limited. Increased groundwater discharge could also positively impact stream temperatures during stressful low flow periods.

CONCLUSION

The functions of the riparian area with respect to the stream environment can be classified into five areas - food, large organic debris, solar energy regulation, streambank and bed stability, terrestrial-aquatic buffer, and streamflow regulation. These functions are highly interrelated as they affect stream habitat and aquatic productivity. Riparian areas provide an important source of allochthonous food inputs and regulate autochthonous production by influencing light levels of smaller forest streams. Riparian vegetation is the source of large organic debris to the stream. Riparian shade is the key regulator of solar energy input and therefore the temperatures of small forest streams. Streamside vegetation is an important factor in maintaining streambank and bed stability and stabitizing large organic debris. Finally the riparian area is a terrestrial-aquatic buffer and influences streamflow characteristics, although these functions may be relatively minor in the undisturbed forested watershed. In general the functional influences of the riparian vegetation decreases as stream order increases.

Providing for totally undisturbed riparian areas is one approach to maintaining the food, temperature, and habitat stability requirements of streams, but does not address timber utilization goals, and does not necessarily lead to optimum levels of aquatic productivity. Research results indicate opportunities exist for timber utilization in the riparian area but at lower intensity and using methods which recognize and meet stream temperature, food, and other stream habitat requirements. In some cases timber management may be designed and conducted to enhance stream productivity. The relationship between riparian vegetation and stream productivity is highly dependent on site specific factors, and likewise, riparian management must be designed on a site specific basis to adequate address timber utilization and stream productivity goals.

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Assessment of Wildlife Damage on Southern Forests

James E. Miller

Abstract. This paper summarizes results from a mail questionnaire sent to forest managers and natural resources agencies in 16 southern States to determine the extent of damage caused by principal wildlife species to southern forests. Annual wildlife damage to southern forest resources was estimated by respondents to this questionnaire to be $11,182,641 with another $1,643,218 annually being expended in attempts to prevent or control damage on 28,380,182 hectares (70,950,455 acres) of forest lands. Conclusions and implications drawn from this and other survey studies indicate that many natural resources managers are reluctant or unwilling to provide monetary estimates of damage caused by vertebrate animals. Reasons for this reluctance are discussed in the paper, however, the lack of practical and effective assessment methodologies or models for determining damage costs is the most significant.

INTRODUCTION

Vertebrate wildlife species have long been considered one of the manageable resources produced on forest lands in the South and many of these have high social and economic values attributed to them by the public, and by the variety of landowners, managers and users. Some wildlife species may at times, however, cause significant economic damage to valued resources and related properties as well as problems and frustration for the landowner, manager and community.

This study was conducted in an attempt to provide some estimates of the magnitude of damage caused by vertebrate wildlife species to southern forests, to delineate some concerns and needs related to the issue, and to encourage stronger consideration of the issue in future natural resources management planning efforts.

The prevention and control of wildlife damage on forest lands is an old and complex problem that rarely is easily accomplished and is commonly misunderstood. It should be a part of any natural resource manager's land management objectives, even though it may be controversial. Wildlife damage prevention and control on southern forest lands is as essential to any comprehensive forest management program as the prevention and control of wildfire, diseases and insect damage. Unfortunately, in the past many natural resources managers, including some wildlife biologists, have perceived wildlife damage prevention and control as detrimental to other management objectives or at best, as an unplanned for, adjunct necessity when damage or losses become significant.

In recent years, however, both natural resources agencies and organizations and most wildlife professionals have come to realize that wildlife damage prevention and control is a vital part of natural resources management. A comprehensive natural resources management plan with objectives for the effective prevention and control of wildlife damage will require a commitment of resources to research and management, a knowledge of current regulations, the capability to assess the cost/benefits of damage/risk and the cost effectiveness of prevention and control methods. As an example, consider the following quote from the (International Association of Fish and Wildlife Agencies 1981), position statement on Animal Damage Control. "A well balanced wildlife management program includes research, the acquisition of land, the development of habitat, the careful regulation of hunting or harvest, the protection of certain species, the enforcement of laws--and the control of animal depredations. Though necessary, this is among the least popular and most controversial of the wildlife management functions. It is, nevertheless, one of the activities which a responsible agency must undertake."

Further evidence of the assigned importance of this management consideration in recent years can

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be found in Department Policy as well as professional society position statements. Two good examples are the U.S. Department of Agriculture, Departmental Regulation 9500-4 Fish and Wildlife Policy (USDA 1983) and the position statement and policy of The Wildlife Society (TWS 1985) adopted on March 19, 1985.

To incorporate an animal damage control program into a comprehensive natural resources management program, questions for consideration are: (1) If wildlife damage prevention and control is a management issue -- do we address and plan for it in our natural resources management objectives? (2) Do we feel confident in our capabilities to assess accurately the impacts of wildlife damage caused by some species and/or wildlife benefits resulting from species-selective, damage abatement? (3) Do we support sufficient research and technology development to establish and maintain efficacious prevention and control measures? (4) Do we have the commitment, training and expertise to implement environmentally safe and cost-effective prevention and control measures to reduce damage/losses to an acceptable level?

Some related facts that we can be confident of, however, include: (1) Wildlife damage has always been a vital element in the protection of human interests; (2) As human populations continue to increase and their needs expand, wildlife species will have even greater frequency of direct or indirect contact and conflicts with humans and their interests in both rural and urban communities; (3) The prevention and control of wildlife damage is complex and can rarely be solved with one universal, simple technique; (4) The problem will rarely solve itself, if ignored; (5) If ignored, it can force the landowner, manager or community to implement control practices that exacerbate the problem, are environmentally hazardous and/or eliminate remaining habitat for all vertebrate wildlife; and (6) Wildlife damage prevention and control measures will always be controversial even though these practices may be essential for effective natural resources management.

STUDY AREA

Federal and State land management agencies and most of the large forest industries in the 16 southern States that make up the Southeastern Association of Fish and Wildlife Agencies were sent self-administered, mail-back questionnaires. The respective States where appropriate personnel were contacted included: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia and West Virginia. Federal and State agencies and the categories of personnel who responded were as follows: USDI-Fish and Wildlife Service, - National Wildlife Refuge Managers; all Region 8 - USDA, Forest Service Supervisors; USDI National Park Service - Supervisors; State Cooperative Extension Service - Wildlife Specialists; State Fish and Wildlife Agency - Directors or staff; State Forestry Commission - Directors or staff; USDA, Animal Plant Health Inspection Service - Animal Damage Control, - State Directors; and Department of Defense - Land Managers. The non-governmental organizations surveyed included professionals from 15 major forest industry ownerships within the 16 States. No attempt was made to survey private non-industrial forest landowners even though they are the principal forest landowners in the South and often suffer the most animal damage losses.

METHODS

The questionnaire was developed by the author with review by Federal and State agency professionals. The purpose and objectives of the questionnaire were delineated on an accompanying cover letter. It was clearly stated on the cover letter that respondents should ... "please answer the questions with the best estimate available from your own personal knowledge or that provided by knowledgeable personnel from your agency or organization." Information compiled from these questionnaires are estimates only of the extent and impact of vertebrate animal damage to some southern forest resources.

Total response to the questionnaire, with explanatory cover letter and self-addressed, postage-paid return envelope was 67%. The exemplary cooperation and support of administrators within the appropriate agencies and organizations is sincerely appreciated. Their support and assistance helped ensure the excellent, short turn-around response to this questionnaire.

The questionnaire consisted of 10 questions regarding wildlife damage and the prevention and control of this damage to southern forest resources. Beginning with the first question, the respondent was prompted to list the acreage of lands by category/ownership where they had knowledge of the extent and severity of damage by vertebrate species to forest resources. The total acres owned/managed or reported by respondents was approximately 28,379,823 hectares (70,125,581 acres) of the total 91,567,705 hectares (226,260,700 acres), or about 31 percent of the commercial forest lands in these 16 southern States (1982 U.S. Forest Service).

Species and groups of vertebrate animals known to cause damage to forest resources in the South were delineated and space for "others" was provided with the request to "specify" if the space adjacent to "others" was checked. For the remaining questions, the respondent was given the opportunity to exercise subjectivity in determining their answers. A figure of greater than $400 damage per year was used to differentiate annual significant damage to forest resources from non-significant. The figure of $400 was selected based on a study of "Landowner Tolerance of Beavers" (Purdy et.al. 1985), which indicated that landowners were tolerant of damage up to the point where it exceeded $400 per year.

The species list of animals known to cause damage to southern forest resources were as follows: white-tailed deer (Odocoileus virginianus); beaver (Castor canadenis); rodents (mice, rats, squirrels, etc.); bear (Ursus americanus); wild or feral hogs (Sus scrofa); rabbits (Sylvilagus spp.); birds (specify); others (specify).

Obviously, evaluation and assessments of damage caused by wildlife are difficult to determine in monetary terms, and few research efforts have been targeted toward obtaining scientific assessments. This is one of the reasons that an effort was made to obtain best estimates of vertebrate animal damage to southern forest resources with this questionnaire. It further points to the need for additional consideration by researchers to develop better models and/or systems for practical damage assessment that can be used by managers.

RESULTS

A total of 234 questionnaires were forwarded to the various Federal and State land managing agencies and industrial forest land managers. Ninety-eight of the 157 respondents (62%) indicated significant damage (e.g., more than $400) caused by one or more vertebrate species during the past 12 months on portions of 26,880,776 hectares (67,201,940 acres). Thus, 59 of the 157 provided no monetary estimate of significant damage to forest resources caused by vertebrate species on 1,499,406 hectares (3,748,515 acres) (Table 1). The total acreage owned, managed or reported by respondents was 28,380,182 hectares (70,950,455 acres), or about 31% of the commercial forest lands in these 16 southern States (U.S. Forest Service 1982).

As reported in numerous other studies (e.g., Woodward 1985), many respondents were neither confident in assessing damage caused by vertebrate species nor were willing to provide economic estimates of such losses even if willing to report that damage was extensive. Thus, some respondents reported little or no damage whereas previous studies in their State have documented millions in damages. It was also evident that some respondents may not have correctly interpreted the question. Where damage estimates were less than the estimated control costs, either the damage was apparently underestimated, the control implemented reduced the damage significantly, or damage was being caused to roads or other property not interpreted as impacting on forest resources. Other conclusions are that damage prevention or control can be so effective that subsequent damage is insignificant or it is not cost-effective as reported for some species. Another possibility is that control is being implemented out of frustration or to prevent expected damage. Frustration and anticipated damage are legitimate reasons to effect prevention or control measures, but difficult to estimate in monetary figures, e.g., periodically having to clean out culverts, or significant damage on adjacent properties.

Respondents estimated annual damage to southern forest resources from all vertebrate wildlife species at $11,182,643. They further estimated another $1,645,218 expended in prevention or control efforts over the past 12 months (Table 2).

Respondents to this questionnaire reported the beaver as causing the most significant damage, estimated at $10,162,263 annually to southern forest resources. Other species of wildlife reported by respondents as causing significant damage in descending order of annual dollar estimates are: white-tailed deer; birds; "other" wildlife; rodents; rabbits; wild or feral hogs; and bear (Table 2).

By far, the species of greatest interest and significance in recent years to southern forest managers has been the beaver, as was confirmed in this study. Review of the Southern Journal of Applied Forestry paper titled "Beaver Damage to Non-Impounded Timber in Mississippi" (Bullock and Arner 1985) reported "Computations made with the lowest (stumpage) value of nearly $87.00/acre estimate the total value of non-impounded timber damage by beaver to be nearly $215 million, occurring over a period of at least 10 years." Other surveys, research and papers reported in the literature substantiate the significance of beaver damage to forests in the South. Earlier studies (Arner and Dubose 1980) projected annual timber damage caused by beaver to be $17 million in Mississippi and (Godbee and Price 1975) estimated annual total timber losses at $45 million in Georgia.

Significant damage caused in the South by beaver to timber through flooding, girdling, cutting, and other damage including roads flooded and culverts stopped up has been reported since the mid-sixties, and, in fact, some forest industries had contracts for control of beaver even earlier. The status of beaver today across most of the South is that viable populations exist in almost every suitable habitat.

In terms of estimated annual expenditures for prevention and control efforts, the total for each species in order of magnitude were as follows: beaver; followed by wild or feral hogs; white-tailed deer; rodents; rabbits; "others"; birds; and bear (Table 2). The estimated cost of prevention or control of wild or feral hogs was over 3 times greater than the estimated damage losses and more than double for bear. For all other species, the estimated costs of control were exceeded substantially by the estimated damage losses, which is more commonly the situation with efforts to prevent or reduce significant damage.

As previously reported, 59 of the 157 respondents either had no significant damage from vertebrate wild species or were not comfortable in estimating the damage in monetary terms, even when the cover letter clearly emphasized that only their best estimates were being requested. Some of the respondents who would not make a monetary judgment that damage exceeded $400 per year would point out that although damage caused by one or more species was extensive, they would not attempt an estimate. In response to other questions, some reported damage caused by wildlife as being extensive but added that they were not comfortable making a monetary estimate of the damage. Others questioned whether the damage estimate was only for trees killed or if it included yearly production lost from flooded lands. Still others simply admitted that they were unable or unwilling to calculate the loss or to determine the number of acres where damage was occurring.

Others indicated that because of their agency's or their own management philosophy, they did not consider depredation or damage caused by any of the species as a problem; the intrinsic or other values these species offered thus outweighed consideration of losses foregone to forest resources. Two respondents reported negligible timber damage but indicated significant damage to roads, depredation to other natural resources, or predation on preferred wildlife species.

Respondents indicated that they would more readily estimate species population trends than attempt to estimate monetary damage. Although only 98 of 157 respondents estimated significant monetary damage to forest resources over the past 12 months, 107 respondents checked one or more trend estimate(s) for species causing damage to forest resources.

Less than one-half of the respondents were aware of the recent Handbook on Prevention and Control of Wildlife Damage (Timm 1984) and fewer had participated in a regional or national workshop or in-service training on animal damage control within the last five years. Of the 149 respondents to this set of questions: 46 either had a copy of the Handbook or access to one; 28 had seen or heard of the Handbook but did not own or have access to one; 77 were not aware that such a Handbook was available; and only 17 of the 149 respondents had participated in a regional or national workshop, conference or in-service training on animal damage control within the last five years. These findings indicate the level of interest in, and need for, increased access to quality information about animal damage prevention and control and greater participation in workshops and other in-service training in this subject by forest resource managers. Most of the 77 respondents who indicated they did not know that the Handbook was available indicated an interest in finding out how to obtain a copy.

CONCLUSIONS

Although the scope of the questions asked, the list of potential respondents surveyed, and the validity of the estimates in this study were limited, some general conclusions are implied. Apparently many professional land managers are not comfortable in answering detailed and complex questions requesting monetary estimates of animal damage to forest resources. There could be a variety of reasons for the reluctance to respond to such questions, however, I believe it is safe to assume that the most common reasons are: (1) Most of us would like to have hard data (which is rarely practical); (2) Viable damage assessment methodologies or models are not available for practical use; (3) Few of us have really been required to evaluate animal damage losses/costs or the cost-effectiveness of prevention and control practices; and (4) Even though managers may have reasonably accurate estimates of the monetary value of a forest stand, they are still reluctant to estimate the monetary loss of wildlife damage caused to that stand, unless specificially required to do so.

Some other conclusions drawn by the author during the course of this study are as follows:

1. Without question, beaver is the vertebrate animal causing the most damage to southern forest resources at the present time. From respondent's answers regarding population trends, beaver is also the species most often reported to have increased over the past five years. White-tailed deer was another species named by respondents as increasing significantly, and in the "other" category, several respondents listed the increasing coyote (Canis latrans) population as a concern because of predation on preferred wildlife populations.

2. When examining comments to the questionnaire, it was evident that wildlife damage losses and frustrations caused to a landowner or manager cannot and should not be evaluated in terms of averages, either regionwide or statewide. Each case must be evaluated on-site as to the magnitude of damage and cost-effectiveness of prevention or control.

3. There is a significant need for development of practical and effective vertebrate animal damage-loss assessment techniques and methodologies and for the determination of the cost-effectiveness of prevention and control measures.

4. Although several institutions are expanding their curriculum to offer courses in animal damage control for natural resources managers, there remains a significant need for in-service training for on-the-job professionals.

It is evident from previous studies reported in the literature that the prevention and control of vertebrate animal damage losses is an essential element for people's well-being, whether to prevent losses to agricultural crops, livestock, forests, desired wildlife habitats, other properties, or to prevent disease epidemics and other health hazards. It is time that natural resources managers cooperatively take the initiative to encourage and support necessary research, development, operational, technical assistance and educational programs in wildlife damage prevention and control.

Table 1.--Responses to questionnaires concerning vertebrate animal damage in southern forests

Affiliation	Total Respondents	Response (%)	Reporting 1/ Significant Damage		Reporting No Damage	
			Number	Hectares	Number	Hectares
National Wildlife Refuges	45	63	22	196,214	23	68,957
U.S. Forest Service	15	94	12	3,452,551	3	285,330
Military Lands	37	62	21	367,456	16	280,235
National Park Service	6	75	3	57,063	3	645,901
State Fish and Wildlife Agencies	11	69	6	217,330	5	No Esti.
State Forestry Commissions	11	69	6	9,044,266	5	214,936
State Extension Service Specialists	9	56	8	87,998	1	No Esti.
Animal Plant Health Inspection Service Animal Damage Control State Directors	10	71	7	7,527,019	3	4,047
Forest Industry	13	87	13	5,930,879	0	0
TOTAL	157	67%	98	26,880,776	59	1,499,406

1/Significant damage was that exceeding $400; no damage means less than $400

Table 2.--Monetary estimates of damage and control efforts for wildlife in southern forests

Species	Damage ($)	Prevention or Control Efforts Implemented	Control Efforts ($)
White-tailed Deer	420,800	Yes	69,000
Beaver	10,162,263	Yes	1,368,683
Bear 1/	1,100	Yes	2,250
Wild or Feral Hogs 1/	40,100	Yes	126,700
Rodents 2/	121,100	Yes	31,450
Rabbits	91,500	Yes	21,400
Birds 3/	222,000	Yes	7,900
Others 4/	123,780	Yes	17,835
TOTAL	$11,182,643		$1,645,218

1/ Estimated costs of control efforts exceeded total damage losses estimated. Although several respondents knew the expense of control efforts for these species, some were reluctant to estimate the monetary damage incurred.

2/ Other rodents specified included voles and pocket gophers.

3/ Birds specified included woodpeckers, blackbirds, goldfinches and mourning doves.

4/ "Others" specified included cattle, feral dogs, javelina, and coyotes.

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The Influence of Silvicultural Practices on Fisheries Management: Effects and Mitigation Measures

Monte E. Seehorn

Abstract.--Silvicultural operations often create severe impacts upon aquatic communities. This paper addresses basic requirements of several species of fish and points out some of the impacts caused by silvicultural activities. Methods or techniques for reducing level of impact are presented.

INTRODUCTION

Stream fishery management, for descriptive purposes, can be separated into population and habitat management programs. Population management refers to the manipulation of populations through application of harvest laws and regulations. Habitat management, although indirectly affecting population structure, refers to actions that maintain or modify the overall stream environment. Habitat management consists of protection and enhancement programs. Protection is often considered as maintaining the *status quo*, while enhancement programs are designed to improve habitat conditions. The difference is not always clearcut, because, in some cases, protection of existing habitat ensures gradual improvement or enhancement over the long term. A major distinction in objectives is that protective programs consist of those measures taken to safeguard fishery resources from concurrent land use or forest management programs. Direct enhancement activity, in contrast, may be performed independently of other program activities. This paper deals primarily with the protection of fish habitat from impacts resulting from silvicultural activities. Various strategies for reducing or mitigating such impacts are presented.

HABITAT REQUIREMENTS OF FISH

Southeastern fisheries include habitats ranging from subarctic to subtropical conditions. Appalachian brook trout (*Salvelinus fontinalis*) found at elevations exceeding 5,000 feet contend with climatological features equivalent to those in southern Canada. Bowfin (*Amia calva*) thrive in subtropical conditions, at the other end of the spectrum. Stream gradients range from precipitous waterfalls in the mountains to barely flowing Coastal Plain streams with gradients of a centimeter per kilometer. Maximum stream temperatures range from less than 15 °C to more than 30 °C. With the extreme diversity of habitat conditions and resultant diversity of organisms, formulating guidelines suitable for protection of all species is a difficult and complex task.

Thermal Requirements

Thermal criteria for representative species or species groups are shown in table 1. These criteria are very general and based upon various studies (Cincotta and Stauffer 1984, Lee and Rinne 1980, Moyer and Raney 1969, McCormick and Wegner 1981, Wrenn 1980) and my field observations. The limits shown are not absolute because factors such as water quality, age of fish, acclimation time, and duration of maximum temperatures affect tolerance. Other associated species may have broader or narrower limits.

All fish seek habitats that meet their own thermal preferences even if tolerance limits are relatively broad. Removal of shade and the resultant increase in stream temperature can cause fish to migrate. Greene (1950) cited a study in the Great Smoky Mountain National Park

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Table 1.--Thermal requirements of representative species and groups of fishes

Species or group	Degrees Centigrade	
	Maximum	Optimum
Brook trout (*Salvelinus fontinalis*)	21-24	13-15
Brown trout (*Salmo trutta*)	21-26	15-17
Rainbow trout (*Salmo gairdneri*)	21-26	15-17
Smallmouth bass (*Micropterus dolomieui*)	30-33	24-29
Redbreast (*Lepomis auritus*)	30-33+	24-29
Redhorse (*Moxostoma* spp.)	30-33	24-30
Redeye bass (*Micropterus coosae*)	30-33	26-29
Spotted bass (*Micropterus punctulatus*)	31-33+	26-30
Largemouth bass (*Micropterus salmoides*)	31-33+	26-30
Bluegill (*Lepomis machrochirus*)	31-33+	26-30
Golden Shiner (*Notemigonus chrysoleucas*)	34-36+	16-23

in which upstream migration of brook trout was simultaneous with removal of shade. He noted another study in Pennsylvania where brook trout emigrated from a section of stream because of severe overbrowsing of streamside willows by deer.

In some southeastern streams, brown and rainbow trout reproduce and sustain themselves in water temperatures occasionally exceeding 24 °C. The key to survival under such maxima is the diurnal temperature fluctuation in which nighttime temperatures drop to 20 °C or less. A study (unpublished data) of a small stream in northeast Georgia illustrated graphically the importance of this fluctuation. Small (approximately 2 hectares) impoundments were constructed on four headwater streams containing rainbow trout. The maximum temperature recorded above either impoundment in the warmest 2-week period was 19.6 °C with minimums several degrees less, while below the impoundments maximum temperatures ranged from 22 to 23 °C. In a normal situation, these downstream maximums would stress, but not likely, eliminate trout. In this case, trout were eliminated in the sections immediately below the outlets becase of the high *minimum* temperature. The impoundments, acting as a heat sink, eliminated the normal fluctuation and held temperatures to 21 °C or above for the entire 2-week period.

Small changes in stream temperatures also have subtle to dramatic impacts upon other components of the aquatic community. Wojtalik and Waters (1970) found that as the temperature increased there was a serious depletion of the mayfly *Baetis vagans*.

Spawning Requirements

Stream salmonids require a clean gravel substrate in which to deposit eggs. A redd several inches in depth is excavated in small to medium size gravel. Eggs are then deposited, fertilized and covered with gravel displaced from redds constructed immediately upstream. For optimum survival the gravel interstices must remain free of fine sediment in order to allow unrestricted circulation of water to the eggs and escapement avenues for fry upon hatching. An increase in sediment less than 0.85 mm is especially critical.McNeil and Ahnell (1964) showed a sharp increase in trout fry mortality when these fine sediments exceeded 20 percent of the total substrate. Irving and Bjornn (1984) reinforced these conclusions, indicating significant reduction in survival of three species of salmonids with an increase in sediments less than 0.85 mm in diameter. In their study, particles 0.85 to 9.5 mm had relatively little effect upon survival. Witzel and MacCrimmon (1983), in a different approach, showed brook-brown trout survival of 0 to 20 percent from hatching to emergence in unigranular gravel 6.2 mm or less, and in multitextured gravel with 60 percent or more sand. Survival was 60-90 percent in 9.2 mm gravel and gravels with 20 percent or less sand.

Spawning habits of riverine darters (*Percidae*) vary widely by species. Some scatter their eggs above the substrate, some bury their eggs, some place them between angled rocks and the substrate, and some cluster them on the underside of stones. Those species that bury their eggs and attach them to the underside of stones require relatively sediment free substrate for the same reasons necessary for salmonid survival.

Stream centrarchids such as bass and other sunfish also require firm substrate for spawning. Beds are usually fanned out in gravel where available, although sand is utilized *in lieu* of coarser materials. The eggs are then deposited, fertilized, and guarded by the male until the fry hatch. Although not as critical to survival of eggs and fry as in the salmonids and some of the darters, heavy deposits of fine sediments blanketing the beds likely reduce survival. For spawning and other reasons, species such as smallmouth bass (Rankin 1986, Paragamian 1981) and redeye bass occur only in streams or reaches of streams with predominately gravel and larger rock substrate. Even spotted bass, which proliferate in a variety of habitats including sandy coastal plain streams, seem to prefer such habitat if available.

Redhorse suckers, madtoms (Noturus spp.) and other species of fish also use gravel and rubble shoals or riffles for spawning purposes and are likely to be adversely affected by increased sediment loads.

Food and Cover Requirements

Many species of juvenile fish, including trout (McCrimmon 1954), rely heavily upon clean gravel riffles for cover during early life stages, while some darters and madtoms spend their entire lifespan in this habitat. In addition to the fish cover provided, this type substrate is an ideal medium for invertebrate production.

As winter temperature drops into the 5 to 10 °C range, metabolic rates of fish decrease, reducing food requirements and lowering swimming ability. Under such conditions, cover or shelter becomes especially critical (Mason 1976). At temperatures less than 4 to 6 °C, juvenile salmonids enter crevices in the substrate to survive icing and concurrent harsh winter conditions (Bjornn 1971). Larger fish, including stream bass and other sunfish, react in a similar manner by moving into deeper pools containing shelter in the form of large cobble, boulders, and logs. Soil erosion and resultant stream sedimentation that fill the substrate interstices destroy this critical component of the habitat.

The higher turbidity accompanying erosion also has a negative effect upon sight feeders such as bass, (Buck, 1956) bluegill (Gardner 1981), and trout (Sigler and others 1984). Juveniles are most seriously affected, but growth rates are reduced even in adult fish. Gradall (1982), in a laboratory experiment pointed out the strong possibility that increased turbidity likely favored production of creek chubs over brook trout.

Numerous studies point out the value of woody debris as a component of quality fish habitat (Sedell and Swanson 1982, Angermeir and Karr 1984, Bryant 1985, Coulston and Maughan 1983). In addition to the cover provided, snags and other woody debris are also important in relation to invertebrate food production. Benke and others (1985) illustrated this in a study of the Satilla River in Georgia. He stated that instream snags supported 60 percent of the total invertebrate biomass, and that the major fish species obtained at least 60 percent of their prey biomass from these snags.

POTENTIAL SILVICULTURAL IMPACTS

Removal of Shade

Shade removal can severely impact fish populations by increasing stream temperature. Numerous studies have documented increases of 4 to 10 °C after shade removal (Brown and Krygier 1970, Burton and Likens 1973, Swift and Baker, 1973, Swift and Messer, 1971). Increases of such magnitude would have severe impacts upon all aquatic organisms. Swift (1982) observed temperature increases at least 5 years after shade removal, although maximums were reduced each succeeding year because of the regrowth of vegetation. Slash burning can amplify stream temperature increase after shade removal. Levno and Rothacher (1969) found that the maximum temperature increased by as much as 7.7 °C after broadcast burning of logging slash. A critical factor in this study was that maximums were exceeded by 30 percent (889 hours) of the June, July, and August monitoring period.

Erosion and Sedimentation

Erosion and resultant stream sedimentation is the most common and difficult problem encountered in silvicultural operations. The effects are subtle in many cases, and are hard to detect by normal sampling techniques. Sediment can originate from several phases of the silvicultural operations, but the transportation system needed to implement the operations is by far the major source. As much as 90 percent of the sediment in streams can be traced to the roads, log landings and other components of the transportation system (Packer and Christenson). Cederholm and others (1981) pointed out that where roads exceed 3 percent of a basin area, fines are consistently higher than normal and, where as much as 4 percent of the drainage is in gravel-surfaced roads, sediment production is increased by a factor of four. The same study showed fish survival to emergence decreased by 2 to 4 percent for each 1 percent increase in fines less than 0.85 mm.

McMinn (1984) in a North Georgia study measured 37 percent soil exposed and 25 percent dislocated in a tractor operation removing 27.6 cords per acre from upper piedmont slopes ranging from 18 to 22 percent. In a concurrent sale using a Bitteroot skyline miniyarder to remove approximately 14 cords per acre from mountain slopes ranging from 24 to 42 percent, only 1 percent of the soil was exposed and none was dislocated. Although volumes of timber removed were not equal, the disturbance in proportion to cut was much greater on the tractor operation. Klock (1975), in summarizing the results of seven studies, showed less than 5 percent deep soil disturbance on sale areas when utilizing balloon, helicopter and some skyline cable systems. Soil disturbance on high lead cable and tractor operations ranged from 15 to 20 percent and 20 to 35 percent, respectively, because of the more extensive transportation systems required.

Kochenderfer and Helvey (1984), after measuring soil losses from 11 road sections in the central Appalachians, reported an average of 16.3 metric tons of soil per hectare lost annually from ungraveled sections, and only 1.98 metric tons per hectare lost on sections surfaced with clean 3-inch stone. Swift (1984) found soil losses of approximately .018 metric tons per ha from a well graveled (15 cm deep) roadbed per 2.54 cm of rain, compared to .308 metric tons for grassed roads, and .499 metric tons for bare soil roadbeds in the southern Appalachians. He pointed out that in the third year a thin layer (5 cm) of rock was little or no better than bare soil.

Heidsdorf (1984) presented the potential advantage of using skidders with wide, high flotation tires instead of conventional tires with front chains on swampy ground. Productivity was increased and previously inaccessible stands became operable with a substantial reduction in ground disturbance and compaction.

Biller (1984), in a study in the mountains of Virginia, compared road requirements for an FMC FT-180C[1] high-speed, low-pressure skidder versus a rubber-tired skidder. The FMC required 42 percent fewer skidroads than the rubber-tired skidder while operating on grades ranging from 10 to 44 percent. The reduction in roading makes possible a significant decrease in overall disturbance. This type equipment, although having some advantages over rubber-tired skidders, can also create erosion problems if not used properly. Sidle and Drlica (1981) measured bulk densities of soils utilizing both uphill and downhill skidding with the FMC. At the 7.5 cm depth, nine passes increased bulk density for downhill and uphill yarding by 25 percent and 45 percent, respectively. Eighteen passes increased bulk density 25 percent at 22.5 cm. With only three or four passes however, bulk densities increased only 10 percent throughout the first 30 cm of mineral soil.

Mechanical site preparation has been documented as one of the more serious contributors of sediment in silvicultural operations. Dissmeyer and Stump (1978) presented the following data (table 2) on sediment produced by some of the techniques and equipment used in these operations. Bulldozing in mountain areas was by far the most serious source of sediment. The methods used in bulldozing were similar to shearing and windrowing except that a straight dozer blade was used instead of a K/G or V cutter blade.

Douglass and Goodwin (1980) found that soil loss from mechanical site preparation varied with percent cover and runoff on 16 small watersheds in the North Carolina Piedmont. Average summer ground cover accounted for 75 percent of the variation. They suggested use of site preparation techniques that leave at least 50 percent ground cover.

Douglass and Van Lear (1983) evaluated the effects of prescribed burning on stream water quality in the South Carolina Piedmont. They found no significant change in water quality. With proper precautions, prescribed burning should be feasible even on fairly steep terrain. If burns are hot enough to destroy the entire surface litter, however, serious erosion may occur.

Effect Upon Streamflow

Removal of the canopy on an entire watershed significantly changes streamflow patterns. Low summer flows may be doubled with less than 10-percent increase in peak flows in Appalachian Forests (Hewlett and Helvey 1970). Although clearcutting 50 ha in a 5,000 ha watershed would have no measurable effect upon discharge, cutting 50 ha in a 250-500 ha watershed may have a significant effect. Douglass (1979) calculated the potential gain in water yield between 20 year and 300 year timber rotations on 2,560 ha to be over 4.18 million liters per day. Clearcutting drainages as small as 8 ha in the Appalachians can change streamflow from ephemeral or intermittent to perennial until regrowth occurs. Douglass and Swank (1975) presented an equation for predicting annual increase in flow based upon percent basal area cut. They also pointed out that conversion from hardwood to pine decreases streamflow by increasing interception and evaporation rates due to the greater surface area of the pine needles compared to hardwood leaves. This decrease is most evident in winter months although flow rates are decreased throughout the year.

Nutrient Export

Studies at the Coweeta Hydrologic Laboratory in North Carolina (Douglass and Swank 1972, 1975) and at the Fernow Experimental Forest in West Virginia (Aubertin and Patric 1974) indicate comparatively small nutrient losses from clearcut areas. The Fernow study indicated a net loss of only 3.4 and 2.8 kg per ha more nitrate-nitrogen and calcium from a cut area than a control area in the first 34 months. These losses decline as regrowth occurs. Swank and Caskey (1982) showed a twentyfold increase in export of nitrate-nitrogen from a clearcut hardwood forest in a second order drainage, although total loss was less than 1 pound per acre annually due to naturally low nitrogen levels and instream depletion.

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[1] The use of trade or firm names is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Disturbance	Period (yrs.)	Coastal Plain	Piedmont	Mountains
Natural	-	.00	.00	.00
Grazing	-	.16	.95	
Logging (excl. rds.)	3	.45	.48	1.70
Prescribed burn	2	.15	.14	.16
Chopping	3	.21	.22	
Chop and burn	3	.36	.38	
Shear/windrow	4	.57	1.80	4.00
Discing	4	2.16	4.10	
Bedding	4	.58	-	
Bulldozing	4	.78	1.90	13.70

Loss of Organic Materials to the Stream Systems

Silvicultural operations removing streambank vegetation have other impacts upon fish populations in addition to that of temperature change. Trees falling into streams are the source of large woody debris necessary for desirable fish populations. Many streams lack such debris, due to the removal of all large streamside trees in the logging operations of the early 1900's, and overzealous removal of existing instream debris through various development projects. Existing second-growth stands have not matured enough to be an adequate source of such material. If we continue to remove all large trees from the streambanks, these undesirable conditions will be extended far into the future.

Introduction of Toxicants

Pesticides can be introduced into stream systems through both ground and aerial spray operations. Some, such as 2,4-D derivatives, are relatively harmless, while others such as paraquat are extremely toxic to aquatic organisms.

Disturbing soils in certain geological formations may introduce toxic materials into the aquatic system. Fisheries were destroyed in two Appalachian streams by road construction that exposed Anakeesta/Wilhite formations. Iron pyrite, a component of these formations, when exposed chemically reacts with air and water to produce sulfuric acid. In at least two locations on one road the rock was crushed and used as fill material. Acid leaching from these road fills reduced stream pH drastically, resulting in further chemical reactions that released aluminum, manganese, and other toxic materials into solution.

Diesel fuel, oil, gasoline and sawdust, common to any timber operation, all have the potential for impacting fisheries.

PROTECTIVE MEASURES

Harvest

Regeneration System and Method of Harvest.--The regeneration system can have a direct, site-specific impact upon fisheries. Clearcutting, although viewed distastefully by the general public, has some distinct advantages if certain precautions are observed. Of major importance is the opportunity to reduce overall roading during the rotation. If the even-age system employs clearcutting as the harvest method, it can offer the greatest potential to reduce long-term impacts by requiring fewer entries into a given area. If necessary in highly critical areas, one entry for harvest and regeneration could be made with no interim operations. In a 100-year rotation, that could mean only one entry into the selected stands each century compared to more frequent entries necessary in the single-tree selection system. Shelterwood and group selection fall between the two extremes in relation to roading needs.

Clearcutting, in addition to reducing the number of entries into a forest, also allows a greater choice of equipment in harvest operations. As pointed out earlier, the type equipment used for harvesting significantly effects rates of soil disturbance and subsequent erosion. Where protection of stream resources is critical and land slopes are over 35 percent, helicopter and cable logging are preferable alternatives to tractor or rubber-tired skidder operations. Skyline cable systems should be selected over high lead or jammer systems when available. Helicopter and skyline operations are not economically feasible, however, for all steep-slope sales, or for the majority of thinning and selection cuts. Equipment that has a low impact, as measured in pounds per square inch of the soil surface, is a viable alternative to conventional skidders, on critical areas where cable systems are not feasible. Examples of such equipment include the tracked FMC, and balloon-tired skidders normally used for wet soil or swamp logging.

Rotation.--Lengthening rotations and reducing the number of entries reduces overall roading requirements for a given period. As previously pointed out, such reduction is a major step in the control of erosion and stream siltation.

Operating Seasons.--Operating seasons should be determined by local topography and climate. Logging should be restricted, depending upon the equipment used (cable, tractor, helicopter, etc.) during periods of wet weather.

Site Preparation.--Buffer strip criteria should apply to site preparation operations in addition to harvest activities. No mechanical site preparation should be attempted in the filter or shade strips, and no herbicides should be used in the shade strips.

Prescribed burning normally creates few, if any, problems. However, hot summer burns can destroy ground cover, resulting in significant erosion problems. As a general rule, burns during the growing season should be limited to periods when fuel moisture levels preclude extremely hot burns.

Slash Disposal.--Logging slash in streams, if excessive, creates severe problems for fishes by acting as a sediment trap, a barrier to fish migration, and reducing oxygen content of the water. Conversely, where lack of organic debris is a limiting factor, the judicious selection of a certain amount of this material to be retained in the channel could enhance the fishery. Needless to say, such selection should be guided by individuals with the necessary fishery expertise.

Transportation

System Design.--Roads should be as narrow as possible. On steep terrain, width is critical in minimizing the area of bare soil exposed in cut-and-fill slopes.

Outsloping and construction of "Coweeta" or long, gradual dips at regular intervals should be used to divert water from the roadbed. Inside ditches should not be installed if dips and outsloping are sufficient to prevent water from traveling the roadbed.

Place log landings and mill sets on ridges or points of ridges rather than in ephemeral channels or riparian areas. Such placement will reduce erosion and at the same time will reduce down time during adverse weather conditions. All roads planned for re-entry and all approaches to stream crossings should be gravelled.

Stream crossings.--Use temporary bridges in lieu of culverts on temporary roads. Excessive disturbance is created by installing culverts and the fill material required. They account for some of the more serious sources of sediment from timber sales. When the culvert is removed at termination of the sale, the disturbance created at that time again adds to the sediment load. Temporary bridges may range from two planks across a small rivulet to log stringer bridges on larger streams. Select the simplest structure needed to accomplish the objectives and simultaneously protect the resource at the same time. Ordinarily, structures consist of abutment logs installed on or in each streambank, with two or more stringers, and decking if needed. The key to reducing impact is to place the abutments where they will create the least initial disturbance, and then leave them in place at termination of the sale. Decking and stringers can be removed, if desired, when the harvesting and revegetation efforts are completed. Low water stringer bridges can be used to cross comparatively large streams to reach cutting units that would not be economically feasible to cut if permanent bridges were required. If designed properly, the stringer bridges will stay intact during major floods that often take out conventional bridges. The key to the design is that they be constructed close enough to the water surface so that only base flows pass under. The upstream stringer or stringers should be a few inches lower than the downstream stringers, thus canting the bridge slightly. This design allows all flood waters large enough to carry trees and other major debris to pass safely above the bridge. The slight cant creates downward pressure by the water on the bridge and reduces chance of flipping it out of place.

Revegetation.--The key to stabilization of disturbed areas is to establish ground cover as quickly as possible. Cut-and-fill slopes on permanent roads should be grassed during or immediately after construction. Temporary roads, log landings and other surface disturbance should be seeded and "put to bed" immediately after closure of a cutting unit rather than waiting until the entire sale is completed. To reduce the period of operating time before revegetation, and for optimum erosion protection, the cutting units should be planned as small as is economically practical. In most areas of the South, seeding can be successful throughout the year depending upon the plant species used. The common practice of limiting seeding to short periods in the spring and fall is a major factor in soil loss when sales close during other seasons. Where cutting units will be open for long periods, or operations shut down for any reason, establishment of a temporary cover such as ryegrass is highly desirable. These fast-establishing species should also be included in any mixture of permanent cover crops. Where management of wildlife such as turkey and ruffed grouse are considered, roads planted with the proper mixtures of vegetation will provide food for adults and brood range. In preparing the seedbed, ripping compacted areas and the use of mulch enhances germination and survival. The mulch, in addition, reduces problems with frost heaving.

Streamside Protection

Buffer Strips.--The term "buffer strip" is used loosely even by scientists presenting research results. Quite often it is difficult to determine if authors are referring to shade protection, erosion prevention, or both when they state that buffer strips have been very effective. For the purpose of this paper, buffer strips include both the streamside shade strip and sediment filter strip.

The effectiveness of a shade strip is determined by many factors including tree height, tree species, elevation and aspect. In general, a 10- to 20-meter wide strip on both sides of a stream should provide adequate shading even with selective removal of a portion of the canopy (Aubertin and Patric 1974, Burton and Likens 1973). Retention of a significant portion of the canopy into old growth will also ensure a source of large debris necessary to maintain a quality fishery.

Determining necessary filter strip criteria is a bit more complicated. Soil type, slope, vegetation, rainfall and amount of surface litter all have a bearing upon the extent of sediment movement. Protective criteria should address potential sediment problems in all channels, including perennial, intermittent and ephemeral, that have the capacity to carry soil. A common solution is to establish filter-strip criteria based upon slope and soil erodibility, applying only to perennial and intermittent stream channels. Such criteria may be inadequate where problems with sediment movement in ephemeral channels are not addressed. Ideally, filter-strip width should be based upon site specific conditions. When technical expertise in site-specific application of variable-width filter strips is not available, standard widths based upon slope, soil erodibility, and other factors including those listed above may be the only feasible solution. Swift (1986) suggests guidelines (table 3) for the southern Appalachians and demonstrates the value of several soil-protecting factors such as grass, mulch, brush barriers, and forest litter.

Soil disturbing activities should certainly be limited inside filter strips, but the total prohibition of heavy equipment or certain harvest techniques is not warranted. The objective should be to use the equipment and technique that will create the least disturbance on a site-specific basis.

CONCLUSION

Silvicultural activities, if administered improperly, can create severe impacts upon aquatic communities. Problems most commonly encountered include increased stream temperature through shade removal, stream siltation through soil disturbance, and reduction in availability of large, woody debris through harvest of streamside trees. Problems created by removal of large trees and other vegetation from streamside areas is a serious concern, but can be handled relatively simply and effectively by establishing guidelines for maintaining the necessary vegetative component and then implementing them. Although several researchers recommend wider zones, it appears that a 10- to 20 m wide shade strip on perennial streams is sufficiant to maintain a suitable temperature and provide the large, woody debris necessary for a quality fishery. On extremely small headwaters where volume of flow is so small that fish are not present, and rapid temperature recovery is likely, retention of only understory vegetation may be adequate.

Pinpointing the primary source of erosion and silt deposition from silvicultural activities is relatively easy. The two most evident sources are the transportation system, including all bladed roads, skidtrails, and log landings necessary for harvesting the timber, and the site preparation techniques used in revegetation efforts. Addressing siltation problems created by these operations becomes a complex issue when considering road location, road design, stream mileage, number of stream crossings, crossing design, filter strip criteria, type logging equipment, and revegetative needs. General criteria should be developed for filter strip width based upon slope, soil type and amount of debris and surface litter. These criteria should address problems with silt deposition in ephemeral channels in addition to intermittent and perennial channels. Criteria presented in table 3 should be suitable for Appalachian areas (Swift, 1986).

The following alternatives should be considered when planning silvicultural operations:

Favor cable or helicopter logging over skidders or tractor on slopes over 35 percent.

Choose skyline systems over other cable systems when available.

Consider tracked and balloon-tired skidders that have a low impact (in pounds per square inch of soil surface) on wet and steep slopes when cable systems are not appropriate.

Table 3. Minimum filter-strip width (meters) for graveled forest roads[1]

Filter strip	Percent slope								
	0	10	20	30	40	50	60	70	80
Without brush barrier	13.1	17.4	21.6	25.9	30.2	34.1	38.4	42.7	46.9
With brush barrier	9.8	11.0	12.2	13.4	14.6	15.8	17.1	18.3	19.5

Note: For prescribed burn without brush barrier or forest litter, add 9.4 meters + 2.0 meters per 10 percent slope. For ungrassed fill and unfinished roadbed in winter and early spring, double the table values.

[1] Distances are for roads with grassed banks, either outsloped or drained by ditchline and culvert onto forest floor that is covered by hardwood litter. Storm runoff that does not infiltrate into the forest soil will carry suspended clay and silt particles farther.

Reduce number of entries into the forest.

Use temporary bridges instead of culverts where possible.

Revegetate disturbed areas as quickly as possible.

Do not destroy the litter layer with prescribed burns.

Apply buffer-strip protective criteria to both harvest and site-preparation activities.

Design roads for the minimum width necessary to accomplish the job.

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SECTION IV. AGENCY POLICY AND PRACTICES

Wildlife and Fisheries Management in the USDA Forest Service

Paul Brouha

Abstract.--Forest Service policy for management of wildlife and fisheries resources has evolved in response to legislation dating back to the 1897 Organic Act. That legislative history reflects enduring public concern that National Forests be managed for multiple use. Present policy embodies concerns for plant and animal diversity, maintenance of viable populations, recovery of threatened and endangered species, and management of species in high public demand. Program emphasis and budget increased dramatically in response to the wildlife and fisheries goals stated in the 1975 Forest and Rangeland Renewable Resources Planning Act (RPA) Program. Despite further planned increases in the 1980 RPA Program, since 1980, wildlife and fisheries funding has remained constant while commodity production has been emphasized. Because of this emphasis wildlife and fisheries activities have shifted away from habitat improvement to coordination and mitigation of resource development activities. Public concern about Forest Service programs, especially logging and road building, has increased with the resulting loss of a constituency that would ordinarily support Forest Service fish and wildlife programs. The strength of wildlife and fisheries management in the Forest Service lies in developing closer ties to the user groups interested in these programs.

INTRODUCTION

The National Forest System comprises 77 million ha (191 million acres) of lands and waters presently managed by the USDA, Forest Service under the concept of multiple use and sustained yield of forest and rangeland resources. It was not always so. In 1897, the Organic Act established the purposes of forest reserves . . . "Securing favorable conditions of water flows, and to furnish a continuous supply of timber. . . ." Not until 1905 did wildlife purposes become recognized when President Theodore Roosevelt established a wildlife refuge on a National Forest. In 1911, the Weeks Act authorized National Forest land purchases to ". . . protect . . . denuded lands within watersheds of manageable streams." The protection of fisheries was specifically identified in Title III of the Bankhead-Jones Farm Tenant Act of 1937. Title III "authorized and directed" the Secretary of Agriculture to "correct maladjustments in land use, and thus assist in controlling erosion, reforestation, preserving natural resources, protecting fish and wildlife. . . ."

Throughout this period the Forest Service was was the grand old outfit that started the conservation and "wise use" ethic of land stewardship. They managed and protected the forests, the watersheds, and the wildlife for all Americans to enjoy in perpetuity. To a large degree, the Service was the organizational embodiment of Aldo Leopold's Land Ethic. Actions were motivated by a "resource first" attitude because there were plenty of resources for all.

Then as the United States human population increased and became more mobile and affluent, the National Forests were subject to increasing and competing demands for resources. The Forest Service's ability to manage in this fashion changed. The events that initiated the change had their start with the increased wood demands during and shortly after World War II. The Forest Service did its best to meet the needs of the wartime economy. Roads were constructed and timber harvested, but in the process a whole sector of the economy became dependent on a steady stream of raw materials from National Forest lands. There was no going back; even when other sectors of the public voiced their concerns for other resources.

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Congressional appropriations supported by the timber resource users provided for a continued emphasis on timber harvest. During this period, however, the Bitterroot and Monongahela controversies were warning voices crying out their concerns.

As time passed public concerns resulted in development of the Golden Trout Wilderness; the Rattlesnake Wilderness; RARE I, II, and II 1/2; and the Elkhorns Wildlife Management Area. The acronyms for multiple use and environmental laws--MUSY, NEPA, RPA, NFMA, FLPMA, AND PRIA became familiar as these concerns became articulated as law. Congressional direction, under which the Forest Service managed the tremendous National Forest resources became much more prescriptive. Finally, the Mapleton Decision, access management in Montana, Forest Plan appeals, threatened lawsuits involving the spotted owl and red-cockaded woodpecker, below-cost timber sales, hard-money roads, and at the last, grizzly bear and woodland caribou appropriation use restrictions, all called into question and have redefined the priorities for National Forest resource management in the narrowest sense.

In summary, the Forest Service managing in response to Congressional and Administration direction and pressure from its timber interest constituency, found itself subject to increasing controversy and in danger of losing its broader supporting constituency. This turbulent development of policy continues today with the Forest Service striving to satisfy increasing demands on limited resources and pressure for more balanced multiple use, and for coequal treatment of fish and wildlife resources with other resources. The Forest Service has been listening; progress is being made and attitudes are changing.

POLICY

At present the Forest Service is charged with the following minimum fish and wildlife objectives:

- Provide for diversity of plant and animal communities to meet multiple-use objectives and to preserve the diversity of tree species similar to that existing in the region.
- Maintain viable populations of all plant and animal species throughout their existing range.
- Accomplish feasible steps to recover threatened and endangered species.
- Maintain and improve habitat carrying capacity for species in public demand.

To reach these objectives the Forest Service focuses on habitat manipulation through vegetation management, while the States manage fish and wildlife populations through adjustments of bag limits and seasons. For the Forest Service, the RPA program and the Sikes Act and Forest Plans specifically define fish and wildlife objectives.

PAST PRACTICES AND DEVELOPMENTS

The historic emphasis of the Forest Service program has been on big-game habitat management to obtain greater harvests. Because of an abundance of natural habitats there was little consideration given to nongame species until the passage of the Endangered Species Act of 1973. Fisheries, despite supporting more recreational use than wildlife, and facing rapid expansion of user demand, remained a custodial program focusing more on mitigation of harm from other resource activities than on habitat enhancement to meet public demands. The basic fish and wildlife program centered on coordination with other resource developments and on a small habitat improvement program. With the completion of the 1975 RPA and Sikes Act plans came specific objectives to provide for greater fish and wildlife populations through a substantial increase in habitat management. National goals and Regional objectives were set for individual species and species groups. The Forest Service fish and wildlife budget jumped from $4.7 million in 1970 to $38.7 million in 1980. During that period fish and wildlife biologists staffing was aggressively increased to an all time high of 458 wildlife biologists and 136 fishery biologists in 1982.

Additionally, during the 1970's the efforts by biologists to quantify the effects of management activities on fish and wildlife habitats, to develop species and habitat inventory databases, to classify habitats, and to standardize inventory methods coalesced into the Wildlife and Fish Habitat Relationships System. This system relates information on habitat to the requirement of a particular species through the use of habitat capability models which can be used during land management and project planning to predict the response of a species to a proposed alteration of habitat. Habitat relationships procedures have been applied in decision processes to evaluate potential resource tradeoffs and use conflicts before they occur, as well as to assess cumulative effects of many activities spread over time and space.

PRESENT PROGRAM

After an initial accounting adjustment to separate general administration expenses from the fish and wildlife program budget in 1981, the inflation-adjusted budget has remained roughly constant despite cuts proposed by the present Administration. While staying even may itself be considered a success in these austere times, the current level of $38.8 million is about half the selected 1980 RPA program; specifically for fisheries habitat improvement, current funding is 23 percent of the 1980 RPA program. Of additional concern is that the trend toward increased fish and wildlife habitat improvement, which was started after the 1975 RPA, has been reversed as program emphasis has shifted to support and coordination of increased timber resource development activities. At present, the habitat management program is focused on mitigating effects of development activities, threatened and endangered species recovery, and on species such as anadromous fish for which there is a high public demand. Since 1980 fisheries biologist staffing has been reduced from 136 to a present level of 107, moreover, as wildlife biologist positions are vacated, the positions are not filled. It should be noted that other Forest Service programs have also decreased, however public responses to current RPA and Forest plans have called for an increased emphasis on fisheries, wildlife, and recreation.

The resident fisheries habitat improvement program ($2.0 million in 1986) can best be described as vestigial, and habitat coordination is inadequate because over 70 percent of fisheries personnel work primarily on anadromous fish resources. This emphasis persists despite the fact that resident fish support 14.7 million 12-hour days of recreational use (46 percent of total fish and wildlife use) and demand is increasing 35-50 percent per decade! National Forests contain outstanding wild blue ribbon trout fisheries as well as important warmwater fishery resources that hold tremendous recreation potential.

At present, annual funding of Forest Service fish and wildlife programs is variable and does not enjoy secure funding supported by a broad constituency of user groups. Many user groups do not support such funding because they do not know what is in the Forest Service program for them. As a result, despite detailed planning of habitat improvements and resource development project coordination to meet local demand for wildlife and fishing uses, efforts to enhance fish and wildlife habitat have been frustrated because of the need for internal and external support. On National Forest lands fish habitat capability has declined, and wildlife habitat capability for several desireable species has decreased in more areas than it has increased.

FUTURE POTENTIALS AND NEEDED PROGRAM SHIFTS

The Forest Service has the potential to develop much stronger wildlife and fisheries programs by establishing closer ties to user groups and promoting program opportunities to meet user needs. There must develop an integration of resource objectives with recreation needs. The public must see that the fish and wildlife program is not a mitigation program designed only to support commodity outputs, but one of enhancement opportunities for fish and wildlife resources that are worth investing in and managing. Forest plans and the 1985 RPA Program provide a promise of more emphasis on wildlife, fisheries, and recreation. It remains to be seen if this emphasis will be translated into reality by the fiscal process.

Coalitions of resource conservation groups have only recently begun to rally to support Forest Service fisheries and wildlife programs. Traditionally, these programs have been submerged in a larger "multiple use" resource management strategy focused on timber production. Instead of supporting the funding of wildlife and fisheries enhancements, conservation groups have focused on stopping the logging, road building, mining, and gas and oil development activities they consider detrimental to fish and wildlife resources. As a result, wildlife and fisheries efforts have emphasized mitigating and resolving conflicts. This emphasis has occurred despite growing technical expertise in restoring and enhancing habitat, and a general desire to implement Forest Plans for fish and wildlife programs in cooperation with conservation groups.

FUTURE FUNDING AND MARKETING STRATEGIES

In order to protect base program funding and increase long-term funding, the following "closed loop" funding mechanisms are proposed:

1. Establish a fish and wildlife mitigation and rehabilitation fund from resource development activity proceeds.

2. Establish access/user fees
   a. National Forest hunting and fishing permits.
   b. General recreation user fee

3. Expand the scope of the Knutson-Vandenberg (KV) fund collections to include all revenue-generating resource development activities and to include the area of effects of those activities.

4. Expand the present cooperative challenge grant approach to leveraging program capabilities by the creation of a national trust, similar to the National Endowment For The Arts, which is used to match private and state funds.

In defining a strategy to obtain political support for such "closed loop" mechanisms one must ask "who cares?" Who cares about increased habitat capability for fish and wildlife on the National Forests? The question leads to an important exercise in developing a fish and wildlife program marketing strategy. The obvious answer is, with the exception of endangered species, that the resource user cares. The recreational hunter and fisherman and the person in the supporting service and production sectors of the economy cares. The commercial fisherman, outfitter, and guide who makes his living from the resource and is also the worker in the supporting economies cares. The subsistence user who provides for his family's needs cares. The person who appreciates seeing wildlife and fish in a natural setting cares. The organizations these groups use to express their political desires (IAFWA, Audubon, NWF, TU, NRDC, EDF, TNC, BASS, DU, NWTF, RMEF) must be involved in the program as a matter of their self interest. If no organizations exist to coherently express these desires, they must be developed. In turn, the production potentials of the National Forests to meet these users' needs must be defined and the users enlisted to promote fish and wildlife programs that realize these potentials. As this political support mechanism unfolds, the Forest Service's capability to meet users' needs must be aggressively promoted along with frequent reports concerning the program results of the user groups' efforts in obtaining increases in the products they desire. Finally, the Chief of the Forest Service must communicate his commitment to respond to these user groups throughout the organization. The marketing strategy must be developed and promoted at the National, Regional, and Forest levels in order to be successful. In such a way the fish and wildlife programs detailed in each National Forest Plan can become a reality instead of remaining paper exercises.

Fisheries Management on Georgia National Forests

R. H. England

Abstract.--Fisheries management on Georgia national forests is directed toward protection and enhancement of trout streams, management of trout populations and harvest, and stocking catchable trout to help meet the demand of increasing fishing pressure. Many streams are stocked, but most are managed as wild fisheries. Stream sedimentation is a major concern but current timber and road management policies generally provide adequate protection on national forest land. The future of Georgia's trout resources depends heavily on national forest management practices, and the current planning process places more emphasis on fish and wildlife values than ever before.

INTRODUCTION

A diversity of fish species inhabits Georgia's national forest streams and lakes. Seehorn (1975) lists 158 fishes known or expected to occur within or adjacent to national forests in Georgia. This total includes game fish such as the centrarchid basses, trouts, catfishes, pickerels and various species of bream. For most of these species, the proportion of suitable habitat that lies on national forest land is extremely small compared to the statewide total. Therefore, a relatively small percentage of the state's total management efforts for most of these species is directed toward populations on national forest land. Conversely, the state's best quality trout habitat lies on national forest land and therefore management of national forest fisheries is a major part of Georgia's total fisheries program. This paper focuses primarily on the state's trout program and its relationship to current national forest land management practices.

Approximately 3,860 km (2,400 miles) of streams support reproducing populations of rainbow (Salmo gairdneri), brown (Salmo trutta) or brook trout (Salvelinus fontinalis) in Georgia (Fatora and Beisser 1980). About 60% of this lies within the Chattahoochee National Forest. The brook trout, the only salmonid native to the east coast, occurs only in remnant populations in some 60 small headwater streams that total approximately 130 km (80 miles). The rainbow and brown trout, introduced into Georgia before the turn of the century, had established self-sustaining wild populations in most of the remaining suitable habitat by the time the Chattahoochee National Forest was established in 1936.

Two national forests, spanning 344,291 ha (850,731 acres), are located in Georgia (U.S. Department of Agriculture 1985). The Chattahoochee National Forest covers 301,970 ha (746,158 acres) in the southernmost reaches of the Appalachian Mountains and the upper Piedmont in extreme northern Georgia. The Oconee National Forest contains 42,321 ha (104,573 acres) and lies in the lower Piedmont in the north-central part of the state. Fisheries resources on these lands consist of coldwater, coolwater and warmwater streams and several small lakes. In addition, national forest land borders portions of several large reservoirs, and thus the fisheries resources of these bodies of water are influenced by Forest Service policies and practices.

By Georgia law, wild fish populations are owned by the state (Georgia Department of Natural Resources 1982), and are the responsibility of the state to manage and protect. The agency charged with this responsibility is the Game and Fish Division of the Georgia Department of Natural Resources. At the federal level the Multiple Use-Sustained Yield Act of 1960 included the management of fish and wildlife as a formal responsibility of the U.S. Forest Service (Environmental Law Institute 1977). This apparent conflict in authority is resolved by a formal memorandum of understanding between the two agencies.

POLICY AND PRACTICES

Trout habitat in Georgia is limited, considering that the number of anglers fishing for trout is estimated at over 200,000 annually (Georgia Department of Natural Resources 1986). Most individual streams are small and productivity is extremely low due to low total hardness (England and Fatora 1974, Fatora 1970). Without supplemental trout stocking, many of these streams would sustain only a small portion of the present use. Georgia's management philosophy has been to provide a variety of fishing experiences, including intensive put and take fisheries, artificial lures only fisheries and trophy trout stream fisheries (Fatora 1975), but to avoid unnecessarily restrictive regulations (England 1979). In practice, this had resulted in an intensive stocking program of catchable (23 cm; 9 inch) fish on selected easily accessed streams, coupled with a continuing effort to protect wild populations from habitat degradation and excessive fishing pressure. In addition, habitat enhancement with log and rock stream alteration structures

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has been accomplished in selected stream reaches.

Georgia's general trout regulations consist of an eight fish daily creel limit, no size limit and no bait restrictions except that live fish may not be used. The general trout season runs from the last Saturday in March to the end of October but a number of streams are open to fishing year around. Streams not open year around are closed to night fishing. In addition, special regulations are in effect on ten stream reaches, eight of which are on national forest land. Nine of these streams require the use of artificial lures only and the tenth, on state park property, is restricted to use by children under age 12 and honorary license holders (disabled or over age 65). One stream (Noontootla Creek) is managed as a catch-and-release fishery with a 41 cm (16 inch) minimum size limit. Another (Waters Creek) is managed as a trophy fishery with a 56 cm (22 inch) size limit, a daily creel limit of one fish and other restrictive regulations. Fish in Waters Creek receive supplemental feeding with commercial trout feed.

The pressure on Georgia's trout resources has steadily increased over the years. The state's population stood at an estimated 5.8 million people in 1984, with well over half of these living within a two hour drive of mountain trout streams (Bachtel 1985). Fatora (1983) documented that about 80% of the anglers fishing seven heavily stocked mountain streams were from the metropolitan Atlanta area. Local governments in most mountain communities are constantly looking for ways to attract tourists to generate additional income. At the same time, many of the more influential citizens are in the business of land development, real estate, banking or other growth dependent businesses. The result is a steady increase in demand for outdoor recreation, including trout fishing.

To help meet this increasing demand, the Game and Fish Division stocks catchable trout in 166 streams, small lakes and tailwaters. This stocking typically begins in mid-March and continues until the first of September. Annual stockings in these waters generally total around one million trout weighing about one-third pound each. Approximately 40% of these fish are stocked in streams and small lakes on national forest land.

Trout stocking on national forest land is limited to easily accessible areas that have historically received heavy recreation use. Restricted stocking is used to concentrate hatchery fish in areas where fishermen concentrate, thus maximizing the return to creel of stocked fish. It is also felt that this approach helps minimize the pressure on wild trout populations.

Recent creel surveys estimated a 100% return of stocked trout on five of eight intensively stocked streams, and 62% or higher on the other three (Fatora 1983). These streams were stocked weekly and total season stocking rates ranged from 4,176 to 9,476 fish/km (6,720 to 15,250 fish/mile). Season fishing pressure ranged from 3,216 to 13,719 hr/km (5,175 to 22,077 hr/mile). Mean annual catch rate averaged 0.94 fish/hr, which is comparable to the 0.86 fish/hr average on ten stocked streams in 1958-59 (England 1974). These figures suggest that increased stocking levels have allowed the state of Georgia to meet the demands of increasing fishing pressure without a decline in catch rate.

Other measures of quality fishing, such as a desire to experience solitude or a relatively unspoiled natural environment, have not fared so well. Stream banks and adjacent areas on heavily stocked streams have been heavily impacted by anglers and campers and show severe soil compaction and removal of understory vegetation. This impact has created considerable concern among forest managers, and attempts to mitigate impacts by restricting camping immediately adjacent to streams have been only partially successful. In spite of this recognized impact, these areas appear to be relatively stable, and are not causing significant stream sedimentation. However, many areas of the national forest may be approaching a practical limit in the amount of this type of use that can be supported.

Sedimentation is the single most severe anthropogenic problem affecting Georgia's wild trout fishery. Mountain soils are unstable and highly susceptible to erosion (England 1975). The popularity of the mountains as a recreation and retirement area has been accompanied by an ever-increasing demand for residential and commercial development and road construction. Georgia has a sediment control law that requires local governments to enact their own ordinances to control erosion and requires developers to submit and follow an approved erosion control plan. However, many activities are exempted and the difficulty of enforcement often results in inadequate protection for trout habitat.

While the sediment control problem is most severe on private land, a number of problems exist on the national forest as well. The multiple use concept recognizes many legitimate uses of the forest, and necessitates many compromises by managers of the various resources. For the protection of wild trout habitat an undisturbed watershed is desirable, but for timber or game management or other recreational use, varying degrees of road access are desirable.

Timber harvest and the accompanying road construction have historically caused the worst stream sedimentation problems on the Chattahoochee National Forest. Both even-age management (clear cutting) and selective cutting methods have been employed. Even-age management has received considerable criticism from environmental groups and the general public who view it as an environmentally destructive method of timber harvest. However, road construction or reconstruction appear to be the primary source of stream sediment regardless of the form of timber harvest (Patric 1976, Anderson et al. 1976). In the long run, even-age management practices probably produce less stream sediment than selective cutting because a less complex road system is needed, and any given compartment is entered less frequently for timber removal (Seehorn 1986).

Current timber harvesting guidelines used by the Forest Service in north Georgia are designed to protect streams from excessive siltation by careful placement and design of roads and the use of buffer strips along stream corridors. Such guidelines appear adequate for stream protection, but enforcement is sometimes difficult because of inadequate staff to administer each individual sale. The current land management plan (U.S. Department of Agriculture 1985) identifies major areas of the forest where management for fish and wildlife should receive priority and it mandates the use of trout as management indicator species. This approach will require the Forest Service to implement a program to monitor the effects of timber operations on forest streams.

Habitat enhancements in the form of log deflectors, cover logs and splash dams have been constructed by both the state Game and Fish Division and the Forest Service. An estimated 400 such structures now exist on the Chattahoochee National Forest. The Forest Service has recently used volunteer workers from Trout Unlimited to add additional structures. The beneficial impact of such habitat work has been debated in low productivity waters where food is the major limiting factor. However, in many of these streams there are areas with very little natural cover, and in such areas the addition of cover would appear to be beneficial. The placement of simple cover logs in strategic locations by experienced personnel appears to be the most effective form of habitat enhancement.

Fisheries management activities on the Oconee National Forest have been limited, and generally handled by Forest Service personnel. Several small warmwater ponds are managed through fertilization and aquatic weed control. Most streams in the area are small, with only limited reaches on Forest Service property. The state's management activities on public waters in this area are primarily directed toward large impoundments and are generally not directly affected by Forest Service management.

Considerable shoreline on both national forests borders several large impoundments owned by the Tennessee Valley Authority and Georgia Power Company. The Forest Service operates campgrounds and boat ramps on some of these, and thus exercises some influence on access and use. Construction of reservoir fish attractors has been expedited by the use of brush and tree tops from adjoining national forest land. These efforts have had a positive impact on the crappie fishery of Lake Nottely, a 1,692 ha (4,180 acre) TVA impoundment adjoining the Chattahoochee National Forest (Weaver 1985).

CONCLUSION

In conclusion, most fisheries management efforts on Georgia national forests are directed towards protection and enhancement of the state's trout resource. Cooperative relations between state and Forest Service management personnel are excellent. The current land management planning emphasis used by the Forest Service to ensure stream habitat protection should help protect the national forest trout resource. In contrast, Georgia trout streams on private land are in jeopardy, and both agencies need to look for ways to promote land use practices that will protect these streams from further degradation and at the same time provide for continued public use. The purchase of land or easements along major stream corridors, the provision of erosion control and planning expertise to county governments, and improved water quality monitoring and enforcement are areas that need to be explored.

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TREASURE Forest - Alabama's Unique Approach To Managing Its Forest Resources

Rhett Johnson

Abstract.-- Alabama's private, non-industrial landowners own almost 75% of the nearly 9 million hectares (22 million acres) of forest land in the state. A unique statewide cooperative effort by twelve state and federal natural resource management agencies has attacked the problem of low productivity and low intensity management on these and other forest lands by the implementation of the TREASURE Forest program. The program features interagency teams on the county level working with forest landowners to develop multiple use, sustained yield management plans. Landowners who successfully implement these plans are recognized statewide by an awards program. The program requires the consideration of timber, wildlife, recreation, aesthetics, watersheds, and environmental protection in all management decisions. The impact of the program on the development of Alabama's total forest resource is evident and the program is gaining in acceptance and popularity among all segments of the forest resource management community.

INTRODUCTION

Alabama contains some of the richest natural resources in the continental United States. Of its more than 13 million hectares (33 million acres), about 66% (8.78 million hectares) are classified as commercial timberland (Rudis, et al. 1984). The current Conservation Reserve Program should add another 40,500 hectares (100,000 acres) of marginal cropland to that acreage. These forest lands contain large, healthy, and diverse wildlife populations that are comparable to those of any southeastern state. Forest management varies greatly across ownership categories. Alabama's woodlands, like those of many southeastern states, are largely privately owned. Fully 94.6% of Alabama's forests are owned by private interests, with farmers owning 27.1%, forest industry another 20.6%, and non-farm, non-industrial owners 46.9%. The remainder of Alabama's forests, about 470,000 hectares (1.16 million acres) or 5.4%, are managed by various federal, state, and local governments. The controlling federal agencies include the U.S. Forest Service (3.2%), the U.S. Fish and Wildlife Service, and various branches of the Armed Forces for a total of about 4.4% of Alabama's forest lands. The Alabama Forestry Commission, the Alabama Department of Conservation and Natural Resources, and various other state agencies own about 0.6% of Alabama's forest land and other government agencies only about 0.4% (Rudis, et al. 1984). By most econonomic indices, forest industry is Alabama's largest industry (McKee 1986).

By law, most of the federal lands and much of the state lands are managed for multiple uses, and timber and wildlife fare well on these areas. Typically, forest industries in Alabama manage very well for timber production and practice a level of forest management generally beneficial to many wildlife species. In most cases, however, wildlife is an incidental product and in only a few incidences is it regarded as an income producer. Achieving that status in industry circles seems to be the key to deliberate attempts to improve wildlife habitat. Currently in Alabama, hunting rights and wildlife management are regarded by most forest industries as public relations tools that might or might not return adequate funds to recover the costs of road repair, wild fire, gates, locks, signs, and increased supervision which result from opening lands to public hunting. A few industries, notably Gulf States Paper Company, have made extensive efforts to make wildlife management an integral part of their overall forest management plans with an eye to making it also an income producer.

Without a doubt, the greatest potential for increasing the quality and quantity of Alabama's forest and wildlife resources lies in the private, non-industrial sector. Although some of the best management examples

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may be found within this group, the norm is far below that found among other ownership groups. Much of this 6.5 million hectares (16 million acres) of Alabama forest land is understocked, under-managed, unburned, and probably yielding forest products at about one-half their potential. There are various reasons for this situation, but lack of forest management knowledge and difficulty in obtaining proper assistance can often be pinpointed as the major problems.

ALABAMA FORESTRY PLANNING COMMITTEE

There are a dozen or so state and federal agencies in Alabama that provide natural resource management information and/or assistance to the general public. In many instances, duplication of effort or conflicting information has resulted from this multiplicity of sources. In 1971, in an attempt to coordinate state and federal assistance programs, 12 agencies formed the Alabama Forestry Planning Committee (AFPC) to encourage cooperation and reduce competition between the member agencies in offering assistance to the state's forest landowners. The AFPC is comprised of the following state and federal agencies: (1) Alabama Department of Conservation and Natural Resources; (2) Alabama Department of Education, Vocational Division, Agribusiness Education; (3) Alabama Forestry Commission; (4) Alabama Soil and Water Conservation Committee; (5) Alabama Cooperative Extension Service; (6) School of Forestry, Auburn University; (7) USDA-Farmers Home Administration; (8) USDA-Forest Service; (9) Alabama Agricultural Experiment Station; (10) USDA-Soil Conservation Service; (11) USDA-Agricultural Stabilization; and (12) Tennessee Valley Authority (Wade and Moody 1983).

The committee, consisting of the head of each participating state or federal agency, meets twice a year and formal actions are by consensus. Despite the expected difficulties, this arrangement has proved workable. In 1976, the AFPC appointed two special committees, one to coordinate service programs and the other to coordinate educational programs. In 1983, a third committee was created to coordinate forest productivity programs. These three subcommittees are made up of staff members of the various participating agencies. They meet quarterly and report directly to the AFPC.

In 1981, the AFPC requested that forestry planning committees be formed on the county level. These committees, comprised of the county-level counterparts of the AFPC members, are charged with identifying and addressing forestry, wildlife, and conservation issues in their particular counties. Most Alabama counties have responded by forming such committees. Much of the forestry activity in the state is now initiated at the county level.

TREASURE FORESTS

The AFPC has been involved in several successful programs in its short tenure, but the flagship program, particularly in regard to forest values other than timber, is the TREASURE Forest Program. The very name of the program is an acronym representing multiple use, sustained yield forest management: Timber, Recreation, Environmental enhancement, and Aesthetics for a Sustained Usable Resource. The program was conceived in 1974 and the first TREASURE Forests recognized in 1975. Since that time, about 400 forest landowners have received recognition as TREASURE Foresters.[1/]

In a typical sequence, a forest landowner seeking management assistance is identified by members of a county forestry planning committee. At that time, he is made aware of the TREASURE Forest program and urged to participate. If interested, he is asked to sign a TREASURE Forest Creed which pledges him to the concepts of multiple-use, sustained yield, and protection of environmental quality. The Creed, like the TREASURE program itself, is non-binding. The landowner's property is then listed as a potential TREASURE Forest and he becomes the target of a cooperative assistance effort in developing a management plan for his property that incorporates the precepts of the program. Ideally, the landowner would receive timber management advice from the various forestry agencies represented on the committee, wildlife management advice from Alabama Game and Fish biologists or other biologists on the committee, and general conservation and natural resources management counsel from SCS, ASCS, or Extension experts. Each landowner must identify primary and secondary management objectives chosen from among timber, wildlife, aesthetics, recreation, watershed, and environmental enhancement. After adequate progress has been made toward achieving these management objectives, the landowner may be submitted as a candidate for TREASURE Forest certification. The district TREASURE Forest coordinator, an Alabama Forestry Commission district office employee, then appoints an inspection team for an on-site evaluation of the accomplishments of the landowner. At a minimum, this inspection team must consist of a graduate forester and a graduate wildlife biologist. Other natural resource professionals may also accompany and participate in the inspection.

A detailed inspection record is completed on each property. Information recorded includes acreages, age classes, forest types, and accomplishments in the last five years in timber management, wildlife management, and/or management for other chosen objectives. In addition, forest management plans for the next five years must be prepared, indicating planned

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[1/] Letson, N., State TREASURE Forest Coordinator, Personal Communication, July 1986.

changes in land use, anticipated timber harvests, future regeneration activities, protection schemes involving salvage, sanitation, and wildfire, and the use of prescribed fire as a management tool.

The inspecting wildlife biologist must complete a checklist of accomplishments in wildlife habitat management. Questions cover prescribed burning practices, adequacy of den trees and snags, diversity of stand types and age classes, irregularity of stand boundaries, adequacy of mast production, wildlife species being managed, protection, harvest procedures, population levels, permanent openings, etc. These questions must be addressed by all landowners regardless of management objectives.

A third section of the inspection record summarizes the overall adequacy of conservation practices on the property including protection of soil, water, and air quality, with special attention paid to erosion control and stream protection. General appearance of the property is noted, although comments are generally limited to extremely unattractive situations such as open dumps. When aesthetics or recreation are management objectives, a section on accomplishments in development and management for these resources is completed by the inspection team.

The completed inspection form, with the inspection team's comments and recommendations, is returned to the district TREASURE Forest Coordinator, often with supporting documents from the County Forestry Planning Committee. Use of the property for demonstrations or other educational or research activities is encouraged in the TREASURE Forest program and documentation of such use is also often included in TREASURE Forest applications. The District Coordinator then forwards the application, inspection record, and supporting documents to the State TREASURE Forest Coordinator, a staff forester with the Alabama Forestry Commission.

The TREASURE program is administered by the Services Subcommittee of the AFPC, which is made up of the State TREASURE Forest coordinator and foresters, biologists, and natural resource specialists from several of the member agencies of the AFPC. The Services Subcommittee meets quarterly to evaluate TREASURE Forest nominations received during the quarter. Field personnel are urged to be on hand to answer questions about applications from their respective counties. The subcommittee rules on each nomination and results are returned through the district level to the appropriate counties. Applications may be approved for certification by the subcommittee, deferred for clarification or further information, or disapproved. In instances where nominations are disapproved, county planning committees and landowners are apprised of the reasons for disapproval and strongly encouraged to resubmit the application after corrective measures are taken. TREASURE Forest certification is valid for a five year period. At the end of five years, the property is reinspected to insure its continued compliance with the TREASURE Forest guidelines.

There are about 400 TREASURE Forests in Alabama containing about 202,000 hectares (500,000 acres), and an additional 500 Creed signers striving for TREASURE status.[1] Any forest landowner in Alabama may qualify for TREASURE status regardless of ownership type. All forest land owned in the state must be considered, however, and a minimum of 4.047 hectares (10 acres) is required. The landowner receives several small awards when certified as a TREASURE Forest owner and becomes eligible for statewide recognition. The Helene Mosely Memorial TREASURE Forest Awards provide annual monetary awards to the three TREASURE Forests judged best in their respective districts and additional recognition is given to the landowner judged best in the state. At this point in the program, peer recognition and personal satisfaction appear to be the motivating factors for most TREASURE seekers. Interviews with TREASURE Foresters reveal a general concern for the land and for future generations.

It is revealing that almost 75% of the TREASURE Forest owners list wildlife as either their primary or secondary management objective. Only timber is mentioned more often, with some combination of the two being most common. Under the precepts of the program, the landowner must display numerous positive accomplishments toward his primary objective, several accomplishments toward the management of his secondary objective, and demonstrate management of his property in such a way as to minimize detrimental impacts on all other forest resources. These requirements insure that wildlife values will be at least protected on every TREASURE Forest. Although there was no intent to downplay the importance of other resource uses such as recreation and aesthetics, the TREASURE program places an emphasis on provisions for the protection of timber and wildlife resources.

An integral facet of the program is the presentation of the TREASURE award. Ceremonies with attending media coverage are strongly recommended and the resulting publicity has generated an amazing amount of landowner interest in the program. Some of the most inpassioned and effective spokesman for the program are TREASURE landowners themseleves.

All agency personnel, TREASURE Forest landowners, and TREASURE Creed signers are eligible to receive a subscription to the publication Alabama's TREASURED Forests free of charge. This attractive magazine is published quarterly by the Alabama Forestry Commission and contains management advice for all of the resources covered in the TREASURE program. It is oriented toward the private, non-industrial forest landowner and contains "cookbook" type articles by natural resource professionals from around the state. In addition, one of the TREASURE Forest families is usually featured in each issue.

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[1] Letson, Ibid.

The TREASURE concept has begun to permeate the management assistance efforts of all the individual agencies involved in the program. Landowners participating in industry assistance programs are beginning to request more multiple use management assistance as the TREASURE concept has gained in acceptance and popularity. Many forestry consultants use their records as managers of TREASURE qualified lands as a selling point in their dealings with landowners. The Alabama Forestry Commission has recently contracted with several private consultants to spread the TREASURE doctrine throughout the state. In addition, the Commission has included a TREASURE Forest instructional unit in its Forestry Academy for all new employees. During February and March of 1986, the Services Subcommittee provided a series of training sessions designed to educate county level agency personnel in the administration of the program. These sessions were held in ten locations throughout the state and featured information on the AFPC and its programs, an overview of the TREASURE Forest program, and a detailed "how-to" session on management for each of the resources featured in the TREASURE program. These sessions were designed to enable agency personnel to assist in the development of management plans that would lead to TREASURE Forest certification. In addition, the sessions were expected to better prepare potential TREASURE Forest inspectors for evaluating TREASURE Forests.

The impact of the TREASURE program on the wildlife management being practiced on the participating forest lands is obvious. Not only is wildlife often a featured management objective, the consideration of wildife habitat and welfare must be a part of every management decision. As the TREASURE Forest program grows, more acreage will be managed in this manner. Still, the acreage actually in the program is relatively small and does not reflect its impact on the management being practiced in the state. Many landowners and managers, although not active participants in the TREASURE program, have begun to adopt the concept in their management. General acceptance of multiple-use management has been increased through the program and through the emphasis placed on it by the member agencies of the AFPC in their everyday landowner assistance activities.

The Alabama Forestry Commission has taken the lead in implementing the TREASURE concept, but the key to the ultimate success of the program is the involvement of all management agencies, particularly on the county level. One of the highlights of the program is the appreciation gained by the members of the various agencies for their counterparts in other agencies. The interdisciplinary exchanges have been particularly rewarding for all involved, increasing understanding among natural resource professionals of the management implications of the various interrelated forest resources. The interagency nature of the program makes it unique and the coordinated, cooperative effort is appreciated by landowners. Many landowners may never make it into the TREASURE program, but, as a result of the TREASURE Forest program, the concept of multiple use management on a sustained yield basis has become better accepted in Alabama as the most desirable forest management goal.

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Cooperative Research and Management for the Wild Turkey

James Earl Kennamer

Abstract.--Public interest and user demand for natural resources have encouraged cooperative and innovative approaches to natural resource research and management. Special interest groups, such as the non-profit National Wild Turkey Federation (NWTF) serve as coordinators and leaders providing the most efficient use of the expertise and monies in behalf of an important resource - the wild turkey. NWTF, through a cooperative approach, sets goals and objectives, identifies and addresses problems, encourages habitat management, facilitates restocking, transfers technology and educates people, maintains library services, and sponsors research.

INTRODUCTION

The European settlers to North America found an abundance of game birds and mammals which rapidly disappeared with subsistence harvest for food and a corresponding loss of woodland habitats as they were cleared for farming and settlements. These game populations reached an all time low during the early part of the 20th century.

In the early 1900s, concerned sportsmen initiated a conservation movement which included harvest restrictions and protection to preserve the few remaining isolated populations of such game species as deer and wild turkeys.

In the 1930s, universities, led in most cases by affiliated Cooperative Research Units and state agency biologists, began efforts to study life histories and subsequent management techniques that would provide benefits to various wildlife species. Techniques to assess habitat conditions, establish populations in unoccupied areas, and monitor individuals were necessary to provide huntable populations of game birds and mammals. As this information was put into practice, through the efforts of state wildlife agencies, the populations began to make a slow recovery.

The wild turkey is an example of a species, numbering about 30,000 birds at the turn of the century, and now has reached population levels of over 2.5 million birds in 48 contiguous states and Hawaii. One of the major factors contributing to this phenomenal increase has been the reforestation of many private, state and federally-owned lands where wild trapped and transplanted birds were released and protected until huntable populations were established.

Early research was aimed primarily at life history studies and solving local problems necessary to determine the effects of potential hunting seasons. Those early studies were followed by research to improve methods of monitoring, trapping techniques, restocking efforts, and range expansion. Most of these studies were done regionally with very little contact or cooperation between states.

Now the time has come for cooperation between resource managers and users to combine their knowledge and efforts to provide maximum benefits for wildlife in general and the wild turkey in particular. Common goals and objectives, information, and practices can be achieved better through cooperative efforts.

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Land practices can be coordinated, agencies can be united in common goals, land managers and resource users can work together, and biologists and researchers can share resources and information for better wild turkey management. Unless land management is coordinated, some practices can offset the gains of another. The effects of clean farming and large-scale conversion of forests to even-aged stands can have negative effects to some wildlife populations. An example of manager/user cooperation, and an example of agency cooperation, is an agreement between the U.S. Forest Service and the NWTF to provide assistance in managing the National Forests so wildlife values will be better enhanced and the negative effects will be minimized.

It is necessary that researchers interchange ideas and expertise to avoid duplication and mistakes. Unfortunately, wildlife research efforts have been conducted with only state boundaries separating similar studies. Budget restraints at all levels demand that cooperative efforts be involved in research and management programs.

The role of special interest groups to coordinate these efforts is becoming more evident. They can unite individuals and diverse agencies, and they can cut through the red tape and politics that have encumbered game management efforts at all levels. They can achieve this through coordination and facilitation, not through usurping other agencies' responsibilities or charge.

NATIONAL WILD TURKEY FEDERATION

The National Wild Turkey Federation was founded in 1973 to work for the conservation of the American wild turkey. The NWTF is a membership-based organization composed primarily of turkey hunters affiliated into state and local chapters. The NWTF works through a national technical committee composed of biologists representing each state wildlife agency. Members of the committee meet annually and communicate regularly to keep informed of current developments, plan activities, and assess and address problem areas. This communication network has provided agencies, managers and researchers collective expertise and resources.

This year, the NWTF, with input from all segments of the organization from the chapter level to the technical committee, has launched into a program that promises to accomplish even greater rewards for the wild turkey. The program will identify major research and management needs throughout the range of the wild turkey, and second, implement a funding program to accomplish these objectives.

The technical committee has identified, and the NWTF Board of Directors has approved, seven major goals and objectives which include:

A. Encourage the conservation and establishment of wild turkey populations using best wild stock available.
B. Assist in acquisition, storage, and analysis of information and equipment needed for conservation of the wild turkey resource.
C. Encourage development of long-term research which will provide information essential to wild turkey management.
D. Encourage protection and enhancement of wild turkey habitat.
E. Encourage the sound management of wild turkey populations.
F. Promote an understanding and appreciation of the wild turkey and its needs.
G. Promote safe and ethical behavior by wild turkey resource users.

These needs have been further defined as to identify national, regional, and individual state priorities.

The NWTF Technical Committee planned and executed the Fifth National Wild Turkey Symposium when it became apparent that the every five year event was in jeopardy of being abandoned. Other workshops in North America concerning wild turkey research/management have been developed. These educational efforts have utilized the collective talents of state and Federal personnel and university scientists to provide the best knowledge available.

The NWTF committee recently completed its second assessment of the current status of the wild turkey in the United States. The 1986 Guide to the American Wild Turkey provides consolidated information concerning state wild turkey programs, from fall and spring hunting season regulations, laws, and includes individual state turkey populations distribution maps.

Recent concerns on the relationship of known commercial poultry diseases, such as mycoplasmosis, to wild turkey populations prompted the committee to undertake a program to train biologists to test for and assess diseases in wild populations, and to evaluate game farm turkeys as potential carriers. The NWTF collects mycoplasma test data from wild turkeys as reported by cooperators for use by resource managers.

The committee has developed a systematic computerized wild turkey bibliography which currently contains over 2000 references. Bibliography searches that once took weeks in a library now can be accomplished accurately in minutes. The second phase of the program is to obtain these publications for a reference library facility at the Wild Turkey Center.

The NWTF has funded 58 wild turkey research projects since 1977 which were recommended by the technical committee and approved by the NWTF Board of Directors. Over $350,000 has been granted to fund research efforts which have national implications. Examples of this research include disease assessment, habitat use, timber management and turkey habitat, effects of roads and strip-mining as they relate to wild turkeys. This figure includes $272,000 in funding, plus vehicles, telemetry equipment, nets, and other equipment purchased by the NWTF and loaned to researchers.

The Grants-in-aid Program, as well as the donation of over 20,000 wild turkey trap and transport boxes to state agencies and researchers, have both been mainstays in the commitment of the NWTF to work for the wild turkey during the last 10 years. The specially made boxes were donated by St. Regis, International, Westvaco, Union Camp, and Meade paper companies.

SUPPORT ACTIVITIES

The second part of the program is to raise the funds necessary to accomplish these goals and objectives. This unique approach is called the Wild Turkey Super Fund. Monies from direct donations and proceeds from fund-raising banquets are deposited in individual state accounts which are administered by the National Wild Turkey Federation.

Before monies can be withdrawn from a state account for a project, the project must be approved by the state chapter president, the particular state representative to the NWTF Technical Committee and the NWTF Director of Research and Management. Approval by the technical committee representative assures that the money will be spent only on projects that will benefit the wild turkey resource. Coordination through the national office makes sure monies will support goals and objectives as approved by the NWTF Board of Directors and the accountability of the money is maintained.

CONCLUSION

The cooperative approach to natural resource management is necessary to protect our resources and meet future management objectives. Private organizations can serve as cooperators, facilitators, fund raisers, lobbyists, and educators. They can interact positively or negatively with other agencies in the best interest of the resource as situations dictate. More than ever before, we must work together to protect our wildlife resources as we face the challenges of the future. Anything less will be a disservice to what so many have worked for in the conservation movement.

Wildlife Management By Champion International Corporation

Charles E. Allen

Champion International Corporation is developing a multi-faceted wildlife program aimed at integrating wildlife and forest management. The program includes: (1) forest management prescriptions to accommodate wildlife, (2) developing land classification and fee access systems and (3) cooperative research to test wildlife management practices. Champion leased approximately 626 thousand ha (1.55 million ac) in the South in 1985. Income varies per ha depending on region and tract desirability. Wildlife management is funded mainly through hunting lease fees generated primarily from local hunting clubs. Indirect returns include customer entertainment on Company lands, promotion of a positive public image and public recognition for its wildlife management practices.

INTRODUCTION

Commercial forest land in the United States is estimated at 195 million ha (482 million acres). Approximately 72% is in private industrial and non-industrial holdings, and 28% is publicly owned (American Forest Institute 1982). Land uses such as urban expansion and reservoir construction (etc.) are eliminating wildlife habitat in the commercial forest land base by .4 to 1.2 million ha (1 to 3 million ac) per year (Tomlinson 1985). The current demand for outdoor recreation promises to intensify. A 66% increase in demand for big game hunting is expected by 2020 (USDA Forest Service 1975). The result has been over-crowding on public land and increased pressure and problems for the private sector.

CHAMPION'S PROGRAM

Outlined in this presentation are Champion International Corporation's wildlife management practices on approximately 2.63 million ha (6.5 million ac) nationwide. It is hoped these comments will be useful to other private land managers.

Wildlife and outdoor recreation opportunities discussed here will focus on game species and activities that generate user fees and income for their management and continuance. Champion recognizes the importance of non-game animals and nonconsumptive recreation such as photography and observation however to date, only consumptive users have provided monetary support for management.

Fiber production is the primary purpose for Champion's land ownership. Wildlife and fish are also important renewable natural resources. After purchasing St. Regis Corporation in 1984, Champion appointed a wildlife programs manager and expanded wildlife operations nationwide.

Timber Management and Leases

Corporate policy states that Company land will be managed for multiple uses. While environmental concerns and promotion of a positive public image are very important, economic justification for wildlife management guidelines is through access fees. Champion promulgates guidelines addressing subjects such as riparian zones, clear-cut size, shape and distribution, and retention of hardwood areas.

Although management varies somewhat by region, land managers in each region are encouraged to protect important wildlife habitats surrounding major streams and drainages and to consider altering the shape and size of clear-cuts to benefit wildlife when possible. Protected riparian zones average from 15 to 61 m (50 to 200 ft) wide. Clear cuts are recommended to be 81 ha (200 ac) or less, irregular in shape with a 5 year age differential to the adjacent stand.

White-tailed deer are a primary game species for hunters in the southern forest. In order to recommend deer management

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procedures, Champion has initiated a computerized data system designed to maintain records of animals harvested on each lease. Lessees, especially those with tracts 405 ha (1000 ac) or more, are encouraged to collect biological information from all harvested deer. Data include field-dressed weights, age, antler measurements, sex, and lactation condition in doe deer. These data are collected by the district offices across the South and are forwarded to Huntsville, Texas for computer analysis. Each lease is sent a summary indicating average weights and antler measurements by age class as well as computer generated graphs comparing these data with previous years. Statistical tests comparing years or adjacent leases can also be performed. This data, combined with deer census information and forest management plans, form the basis for the wildlife plan for each area.

Land Classification and Fee Access Systems

Access fees are realized primarily through leasing to hunting clubs. Champion leased 626 thousand ha (1.55 million ac) from a total fee acreage of 1.05 million ha (2.59 million acres) across the South in 1985. Leasing additional acreage is being initiated or intensified.

Wildlife surveys of Company land indicate leased areas support higher and more diversified game populations than unleased holdings. Lessees develop a surrogate ownership behavior pattern conducive to protection from poaching, trash dumping, arson, and vandalism. These reasons, coupled with economic incentives, are providing the impetus to develop fee access programs in unleased holdings. For example, a 45,000 ha (111,200 ac) free permit area in Washington State adjoining Mt. Ranier National Park is being studied as a potential fee permit area. Campsites, firewood, and hunter check stations are now provided. Hunter management includes designating areas where only walk-in hunting is permitted. Spotlight and helicopter census information as well as biological data from hunter kill provides population status and animal quality data. A contract security man is provided to patrol the area for trespassers and game violators. Cooperative wildlife management with the Washington Department of Game is being studied to produce older aged-class elk (Cervis canadensis) and black-tailed deer (Odocoileus hemionus columbianus) to develop higher animal quality.

Differences in habitat quality and game species diversity affect desirability of various tracts available for leasing. The purpose of our investigating a land classification system is to objectively quantify these differences so that tracts are equitably priced for both the lease holder and Champion. Five different classifications were devised based on a point scoring system. Points are awarded for habitat and wildlife species diversity, hunter accessibility, tract size, site index, and presence or absence of water including fishing opportunities. Conditions that negatively impact the tract's attractiveness are also considered and points are subtracted from the total for adverse situations. Classification categories are expressed as Class 1 through 5. Ranges are 181-225 for Class 1, down to 0-55 for Class 5 land. Prices vary by region but range between $.50 to $5.00 per acre. The system is being tested in selected areas this year. Corporate policy is that local sportsmen shall be given preference in leasing with fees at or below fair market value.

Test Practices and Cooperatives in Research

The Brushy Creek Experimental Forest in eastern Texas is used for forest management, wildlife research and management, and customer and guest hunting entertainment. Forest management consists of a 25-year pulpwood rotation, clear-cutting, site preparation and planting, prescribed burning, and protection of riparian zones. Special practices for wildlife include prescribed burning 5-10% of the area each year and planting chufa, oats, wheat, and clover for turkeys and deer on about 1% of the area annually. Logging operations have been suspended during spring in turkey's nesting areas and regular patrolling of the area and limited access to the public appear to limit illegal hunting.

Wildlife management and research on Brushy Creek are directed at eastern wild turkey (Meleagris gallopavo silvestris) and white-tailed deer (Odocoileus virginianus). Thirty-two wild-trapped turkeys were released on Brushy Creek in 1979. These birds were radio tracked from 1979 to 1983 by Texas A&M University to determine forest habitat use patterns. Information from this study has contributed to knowledge of habitat requirements. Reproduction from this population has been used to restock unoccupied habitat in eastern Texas. More turkeys have been trapped and transplanted from Brushy Creek than from any other East Texas restoration area. This population will continue to be of paramount importance in restocking efforts.

Prior to 1971, Brushy Creek was open to unrestricted hunting and cattle grazing. The area was posted in 1971 and hunting was prohibited until 1977. Grazing has been discontinued since 1977, the deer management emphasis has been to produce and harvest quality deer. Management to accomplish this goal includes maintaining the herd at or below carrying capacity, harvesting at least an equal number of does and bucks and harvesting spike bucks. Census work is performed using spotlight and helicopter techniques. Buck age-class management is by rotational hunting. Brushy Creek is divided into three management units, each approximately 3,100 ha (7660 ac) in size. All areas are hunted for spikes and doe deer depending on the population, but branched antlered bucks are hunted only in one area each year. All hunting is performed by customers and guests. Each unit is not hunted again for three years to allow a higher buck age-class distribution to develop.

This procedure has proven effective. Data from five years indicate that 32% of the bucks harvested have been 4.5 years old or older. A typical 4.5 year old buck from a sample of 46 from Brushy Creek weighed about 49 kg (109 lbs) field dressed, with an inside antler spread of 38 cm (15 in), average base circumference 11 cm (4.3 in), main beam length 51 cm (20 in), and had 9.2 points. From 1977 through 1981, data were collected on 144 bucks harvested from Brushy Creek. Measurement data from these bucks were compared to those of 406 bucks harvested throughout the Pineywoods ecological region and to data from 795 bucks measured in storage facilities in the South Texas Plains ecological region. Deer from Brushy Creek had similar weights but generally had larger antlers than the deer from South Texas.

Cooperative Research and Management

Cooperative research has been conducted with U.S. Forest Service's, Wildlife Habitat & Silvicultural Laboratory (WHSL) in Nacogdoches, Tx. These cooperative projects have proven beneficial from several aspects. Champion obtains information that can be used in practical management applications. The wildlife lab benefits from consultation on experiments, assistance in applying treatments, use of company land, and from information it obtains from Company biologists regarding research needs. Research results also directly benefit the wildlife resource through improved management techniques and ecological understanding. Studies and cooperative work have included economic and biological aspects of green-tree reservoirs (Allen and Halls 1978), dispersal, reproduction, mortality, and habitat utilization of restocked eastern turkeys in East Texas (Hopkins 1981), and development and impact of an industrial wildlife program (Allen and Dickson 1983). Current projects with WHSL include a study comparing hunter success and deer sightings in 10-20 year old pine plantations versus other habitat types.

Management goals of the various state wildlife agencies and Champion are similar in many instances. Wildlife personnel for Champion stress the importance of antlerless deer harvest and other wildlife management techniques to hunting clubs. State biologists and law enforcement personnel are frequently contacted by Champion's personnel developing a positive working relationship. For example, as a result of a proposal by Champion's Wildlife Programs Manager, Champion and the Texas Parks and Wildlife Department are cooperating to analyze the effects of pre-season antlerless deer harvest in East Texas for the 1986 hunting season.

Champion is cooperating with the Montana Fish, Wildlife, and Parks Department on a big-horn sheep restoration effort and investigating cooperative efforts with the Washington Department of Game on aerial census and cooperative management programs for elk and black-tailed deer.

Other cooperative working relationships have developed between wildlife agencies or organizations and Champion. Champion's Wildlife Programs Manager serves as chairman of the Private Lands Committee of the Southeastern Section of the Wildlife Society and works closely with the Wildlife Management Institute. Champion's Wildlife Programs Manager for Texas is involved with the Texas Forestry Association's Wildlife Committee and implements wildlife management activities in Texas.

Customer and Guest Hunting

Product sales and marketing are the heart of any manufacturing company. By offering customers and guests the opportunities to hunt on the Brushy Creek Experimental Forest, the company generates customer goodwill and increased product sales, while maintaining strict control of hunting methods, hunter kill, and biological data collection.

Public Relations

Champion's involvement in wildlife management and research has appeal to many hunting, conservation, and environmental groups. This involvement is publicized by outdoor writers and the news media through the efforts of the Company's Wildlife Programs Manager and its Public Affairs Department. The Company and its wildlife personnel have been recognized for their conservation contributions by the Texas Forestry Association, Safari Club International, Sportsmen's Clubs of Texas, the Texas Outdoor Writers Association, and the Soil Conservation Service. While difficult to measure, these indirect benefits may be even more important to Champion than direct returns from lease hunting.

CONCLUSIONS

Managing the wildlife resource on industrial forest land in a professional manner is providing both direct and indirect returns to Champion. Direct returns are realized primarily from leasing fee access to hunting clubs. The company has successfully implemented programs that help lease holders collect and analyze biological data to improve their recreational experiences. Cooperative management and research efforts between Champion and federal and state wildlife agencies have proven beneficial. Indirect returns include a wide range of benefits, including customer entertainment on wildlife management areas, promotion of a positive public image, and recognition for environmental enhancement.

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Summary and Concluding Remarks

Dan W. Speake

Today's speakers have emphasized that opportunities for wildlife and fish management on southern forests are good and improving. The reasons given for this fortunate state of affairs were several. McKee has shown that landowners can expect profits from timber-wildlife management programs to exceed profits generated from timber alone. Annual fees for the lease of hunting rights have been increasing to the point that it certainly pays for a landowner to consider lease hunting as an annual source of income from forest land between the time of tree planting and harvest.

At the same time the technical information that is needed for the integration of wildlife management with timber management is improving. This information helps the forest manager justify wildlife management practices. R. Johnson has shown how the Treasure Forest program is organized to get technical information out to the persons that actually control the land use of 75% of Alabama forest land. Kennamer has shown us how a special interest group, The National Wild Turkey Federation, has begun to help finance and coordinate research, management and education efforts on a nationwide scale.

Still another positive factor is the improvement in cooperative attitude between the various natural resource groups. Ellis reminded us that disputes between foresters and wildlife and fish professionals over priorities are legendary. Most of the speakers have stressed that cooperation is generally good at this time. Allen said that public recognition may be even more important than the direct returns. His company has cooperative working relations with state and federal agencies, outdoor news media, universities and others. Champion's activities include collection and analysis of data from hunting clubs, support of research and promotion of wildlife management. Hunting lease fees from company lands support this program. Several other industrial forestry companies operating in the south have similar programs. The U.S. Forest Service has a mandate to manage for multiple use of all resources on the public lands under its control.

We could go on pointing out areas where foresters and wildlife and fish managers have interests that are the same but of course there are places where the different values cannot be well managed for at the same time. We cannot have multiple use everywhere, at least not on private land.

I'm sure that most foresters would prefer diversity, abundant wildlife and fish and aesthetically pleasing surroundings if they can bring about such conditions without having to pay too high a price. On the other hand, as S. Johnson pointed out, wildlife professionals have come to see that not all pine plantations are "biological deserts" throughout the rotation and that commercial forestry is much better wildlife habitat than strip mines, large agricultural fields, or subdivisions. When it comes to prescribed burning, Landers stated it well, "prescribed burning is perhaps the most under-utilized but valuable tool available to wildlife managers." Current knowledge of the use of fire for both wildlife and forestry purposes is such that both foresters and wildlifers regard it as an under-utilized tool. Another much under-utilized tool is thinning. Frequently thinning benefits both timber management and wildlife management; in fact there are many situations where burning without thinning is of little value to wildlife habitat.

As hunting and fishing lease holders pay more money and learn more about management techniques that affect wildlife and fish, they will be putting more pressure on foresters to modify some of their practices to benefit wildlife and fish. S. Johnson pointed out the tendency for less intensive timber management on marginal sites which can be beneficial to some species. It might prove more desirable and profitable in the long run to manage some mixed or hardwood stands that have good wildlife value with a selective cutting or group selection system that maintains wildlife habitat values and timber values continually. Some areas such as deep sand ridges and bogs, that often are poor timber sites, could receive special consideration because of their value to rare, threatened or unique plants and animals.

I was much impressed with the comments of various speakers regarding the importance of riparian zones. What emerges from the presentations of Dissmeyer, S. Johnson, Dickson and Huntley, E.L. Miller, Seehorn, and England is that essential fishery values such as food production, water temperature, sediment control and stream flow regulation are protected by almost the same actions recommended for protection of soil productivity, provision of diversity, and retention of the mature forest component for mast and fruit production, travel lanes, and essential habitat for squirrels, turkeys and some non-game species. Surely most of us can agree on the importance of riparian zones, but further research is needed to clarify their values to key wildlife species and to determine how wide they should be for specific purposes. This type of information is especially needed to improve the management of wild turkeys and is being acquired by Dickson and others.

Lest we paint too rosy a picture, it should be acknowledged that many problems exist and many improvements could be made. One problem that has worried me for years is the possibility of severe restrictions on burning that could come about due to public pressure.

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Well-meaning, but ill-informed, pressure groups sometimes act as though they believe that all fires are environmentally destructive. Demonstration and education or re-education will perhaps take care of that. There is the nagging possibility that lawsuits from road accidents caused by smoke or other smoke problems will lead to such restrictions that burning will be practically banned. With the conversion of many upland mixed forests to pine types having a naturally lower wildlife value, we have become more and more dependent on the burning tool for wildlife management. It would be disastrous to wildlife values if we could not use it.

Vegetation control with herbicides can be used to benefit some wildlife species at the same time it benefits timber. However, some of the goals stated in the newspapers by proponents of herbicide use tend to alarm wildlife biologists, hunters, fishermen and nature lovers. If it becomes possible or economical to really remove herbaceous growth from pine plantations for more than a short time or to eliminate woody plant rootstocks altogether from pine plantations then serious conflicts would develop. As McComb and Hurst pointed out, the effects of herbicides on wildlife species reproduction and survival need more research. Even though toxicity levels of the commonly used compounds appear low, we need to be sure of the possible long-term effects on non-target organisms. Land managers that value the use of herbicides as tools should not forget the recent controversy in which the use of 2,4,5-T was lost.

I think that J. Miller is entirely right in criticizing the wildlife community for not adequately encouraging and supporting research and education programs in animal damage control. Wild animals not only sometimes seriously damage timber values but also can limit populations of other preferred and threatened animal species. Where beaver control is necessary it can sometimes be accomplished by organizing trappers in problem areas. Part of the inducement can be permission to take other furbearers such as raccoons, foxes and bobcats. The latter group of species along with wild dogs are frequently important limiting factors on populations of such species as wild turkeys and gopher tortoises. Since man has removed many of the checks on furbearer species and his land management frequently helps bring about an increase in their numbers, he sometimes has to assume responsibility for balancing things.

Free public hunting as we have known it is on the way out. If it becomes economically feasible to manage land for wildlife, then it becomes economically unfeasible for the hunters to have a free ride. To me it is an obvious truth that as wildlife values increase because of rising demand and investments in management, more and more lands will be closed to the general non-paying public. One hears a good deal of grumbling now about, "out of state hunters leasing up all of our land." For some reason the protest is almost always directed toward out of state hunters, but regardless of who leases the hunting rights, some people will be forced out of traditional hunting grounds. For a time there will be trouble over this and public wildlife management areas and other public lands will be heavily impacted. It may become necessary for the state wildlife management areas to increase user fees as suggested by Brouha for the national forests, not only to have funds for management, but to keep private lands in the existing management areas. Ways must also be found for the states to acquire additional lands for public wildlife management areas and for direct habitat improvement to become a better supported activity on national forests.

Many of the speakers today referred to the necessity for site specific evaluations that must be made by individuals with the necessary judgment and technical expertise. As S. Johnson stated, "the responses of vegetation and wildlife to silvicultural practices may differ drastically at different places and different times. Blanket prescriptions don't work everywhere." As the economic values of wildlife and fish increase, the opportunities will likewise increase for skillful practitioners of the art of wildlife management. Good, experienced field ecologists and wildlife managers are in short supply, and many of today's wildlife training programs are not emphasizing management. Managers in the field are frequently moved about so much that they do not get enough on-the-ground experience to develop expertise for a particular environment, or they end up in an office. I believe that foresters should have some training in plant taxonomy and plant ecology to include lesser vegetation as well as trees. Wildlife biologists should be exposed to enough forestry training to at least be familiar with silviculture and have some understanding of the economic reasons for forestry practices.

All of today's speakers referred to the need for research to further define the requirements of wildlife and fish and their responses to management practices. They cited many examples of successful research in recent years and called for additional work to solve specific problems. Recent advances in technology have improved research tools, for example we now have much better radio telemetry equipment for tracking animals than was available just a few years ago. Solutions to many problems will be forthcoming when research is better funded. This is especially true for the non-game and threatened and endangered species which have not been well studied as a group. One of the reasons for this has been that financing has not been as available for research on these species as it has for research on game and sport fish. Sportsmen deserve a great deal of credit for their support of game and fish species, and other interest groups should follow their example. So far most of the research on nongame species has been financed by public agencies but I might mention a notable exception in this region. The International Paper Company (IP) recently spent money to investigate the ecology of the lowly gopher tortoise, a species that is of interest to a relatively few very enthusiastic people. The work was extremely well done and IP was presented with an award by the Gopher Tortoise Council. The affair of the gopher tortoise is not over since it turns out that this species is crucial to the welfare of several rare and at least one threatened species and the tortoise itself is now a candidate for listing as threatened in the western part of its range. There is now a demand for technical information on management of this species that has been supplied in large part from the efforts of IP.

Much more research is needed along the lines of work being done by Tall Timbers Research Station, a private organization located near Tallahassee, Fla. Tall Timbers is involved in long term studies of Southern Coastal Plain ecosystems. They are responsible for much of what we know about the role of fire in coastal plain pine forests. It takes years of study for many of the ecological relationships that form the basis for forestry and wildlife management to be worked out. Short term applied research will not do the whole job.

It might be well for us to consider that technology will not solve all our problems. Some of the most serious ones are social. Natural resource managers deal with a public that is frequently poorly informed but still determined and vocal. Our peculiar system where most of the land and timber is privately owned and the wildlife is state owned can lead to conflicts and controversy unless strong trespass laws exist and can be enforced to protect the rights of the landowner in marketing the opportunity to harvest the wildlife.

In spite of the problems, there is a great potential for wildlife management on southern forests. With the economic value of hunting and fishing opportunity now increasing, I am looking forward to a bright future for these natural resources.

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